Lower White Lick Creek Watershed Management Plan

Morgan County Soil & Water Conservation District

"The mission of the Morgan County SWCD is to develop a watershed management plan based on our understanding of our impacts to Morgan County watersheds and to formulate and implement community sponsored actions to protect and improve water quality"

September 2003 - September 2005

IDEM 319 Project: ARN# 03-771

LOWER WHITE LICK CREEK

WATERSHED MANAGEMENT PLAN

Prepared for:

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September 2005

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EXECUTIVE SUMMARY

Christopher B. Burke Engineering, Inc. (CBBEL) was retained by the Morgan County Soil and Water Conservation District (SWCD) to help lead the investigation, development, and drafting of a Watershed Management Plan (WMP) for the Lower White Lick Creek Watershed. Interest in developing this WMP stems from county-wide efforts, both prior and ongoing, to develop watershed management plans for all watersheds in Morgan County. Thus, this planning effort is part of a vision to provide a comprehensive plan for all watersheds in Morgan County and it is hoped that, through the implementation of this WMP, improved water quality conditions will be realized that will benefit all residents of the Lower White Lick Creek Watershed.

The Lower White Lick Creek Watershed includes drainage area in the southern portion of the greater White Lick Creek Watershed. The Lower White Lick Creek Watershed drains portions of Hendricks, Marion, and Morgan Counties to the East Fork and main stem of the White Lick Creek just prior to the confluence of the White Lick Creek with the White River. The Lower White lick Creek study area covers approximately 44 square miles within the greater 290 square mile area of the White Lick Creek Watershed. Both watersheds are located west and southwest of Indianapolis in central Indiana.

Chapter 1: Introduction describes the planning objective, process, and participation that are pertinent to watershed planning and management. The watershed planning effort began with the organization of a Steering Committee that assessed conditions in the watershed, examined water quality issues important to the community, and made decisions as to the direction and content of the plan. **Chapter 2: Identifying Water Quality Problems and Causes** examines and discusses information that describes the current water quality conditions in the Lower White Lick Creek Watershed. To help facilitate this planning effort, CBBEL researched and compiled information on past studies, analyzed trends, and conducted a chemical monitoring program in the watershed to provide the Steering Committee with a comprehensive picture of water quality conditions in the watershed. General conclusions reported in recent and past studies showed that habitat conditions were good, but aquatic communities were stressed by urban and agricultural activities. Additionally, the chemical monitoring study confirmed that *Escherichia coli (E. coli)* bacterium is a special concern and significant impairment throughout the Lower White Lick Creek and its tributaries. **Chapter 3: Identifying Pollutant Sources** describes the potential sources and possible locations of pollutants that are causing impairment that were identified in Chapter 2. **Chapter 4: Identifying Critical Areas** details general locations where these pollutant sources may be addressed to help preserve and improve water quality conditions in the Lower White Lick Creek Watershed. The Steering Committee considered findings from prior and recent studies and used their first-hand knowledge about the watershed to prioritize water quality issues throughout the Lower White Lick Creek Watershed. Priorities focused on sources of pollutants and the associated human activity for both rural and urban localities. Results of committee discussion yielded a map of critical areas that were recognized as requiring either preservation, or improvement. **Chapter 5: Setting Goals, Management Measures, and Indicators** identifies specific management actions and recommendations for preserving and improving water quality in the Lower White Lick Creek Watershed. Finally, **Chapter 6: Monitoring Effectiveness** defines how the WMP will be reviewed, evaluated, and updated as a living and dynamic planning document into the future.

This Plan is the culmination of a two-year planning effort and is intended to be a guiding document that describes the current water quality conditions, prioritizes water resource issues, and identifies specific management actions that can be implemented to help the Lower White Lick Creek Watershed community manage their water resources into the future. Future watershed management planning efforts could improve on this WMP by directing the planning focus on the upper portion of the Lower White Lick Creek Watershed and then integrated those findings and recommendation with this WMP to provide a more unified planning and implementation effort.

Individuals that are interested in obtaining a copy of the Lower White Lick Creek WMP can contact the SWCD at the following address:

Morgan County Soil & Water Conservation District
1328 Morton Avenue, Suite 2
Martinsville, Indiana 46151
(765) 342-5594, Ext. 3

An Adobe® .pdf file of the Lower White Lick Creek WMP will be made available on the Morgan County SWCD website (http://scican.net/~conservation/SWCD.htm).

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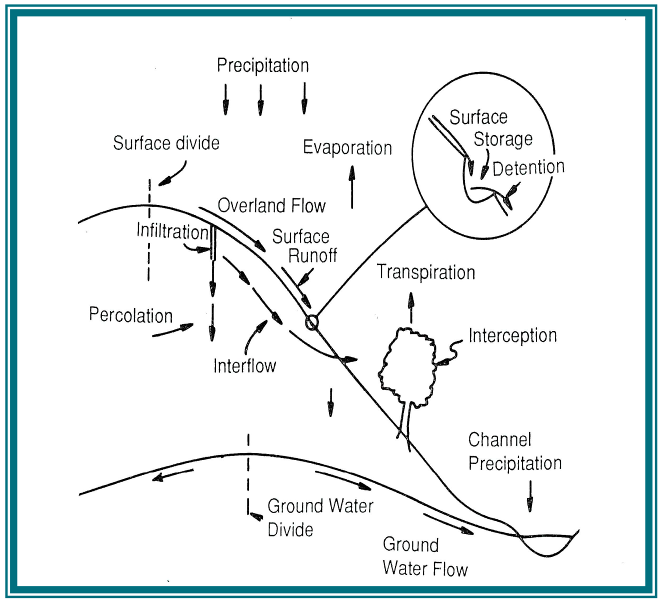
1.0 INTRODUCTION

1.1 WATERSHED BASED PLANNING

A watershed is an area of land that collects and drains water to a specific point. Similar to water poured into a bowl, a portion of the precipitation that falls on a watershed will move through the landscape, collecting and concentrating in low areas, creeks, and streams, until it exits through an outlet point. All water, whether in the ground or traveling over the ground surface, moves from the highest to the lowest points in an area of land. Using this definition, watersheds can be defined for any location. For planning purposes, the watershed is a measurable and practical landscape feature that is based on how water moves, interacts with, and behaves on the landscape.

Exhibit 1: The Hydrologic Cycle



(Haan, 1994)

Water in the form of precipitation can take several paths once it has reached the earth as shown in **Exhibit 1**. Some portion of the precipitation will never reach the ground; instead it is caught by vegetation and/or ground litter and evaporates. That portion of precipitation that does reach the ground can infiltrate the ground, becoming shallow or deep groundwater, or travel over the surface as runoff. Runoff is excess rainfall that can not be absorbed or retained in the landscape. As water travels through the watershed by these pathways it interacts with the landscape, in a physical and chemical manner, that interaction determines the character of water quality in a receiving waterbody. Human activities alter the landscape and thus influence the physical and chemical interaction of water in a watershed. Recognition and an understanding of the hydrologic cycle in the context of human influence on watershed processes are fundamental to good watershed management planning.

Human interaction with the environment helps to define the characteristics of the watershed, and thus, the quality of the water. A logical way to approach water resource management is to use the watershed as the primary management unit. Since water collects and moves through the landscape via watersheds, the physical, chemical, and biological conditions of the water will be unique to each watershed. Therefore, planning and management would be most effective if they address the unique character and conditions of the watershed in question.

Watersheds, and watershed management areas, can be considered at a regional or very local level; where watersheds can be as small as a ¼ acre plot or as large as the Missouri River Basin that covers millions of square miles. The Center for Watershed Protection classifies watersheds into five management units; these are catchment, sub-watershed, watershed, sub-basin, and basin and are listed in **Table 1-1**. The primary planning authority and suggested management focus for each of the five management units varies depending on the size of the watershed. According to this system, the Lower White Lick Creek Watershed has approximately 44 square miles of drainage and would be classified as a Watershed and is therefore would be best managed at the local or multi-local level.

Table 1-1: Watershed Management Units

Watershed Management Unit	Typical Area (sq. mi.)	Primary Planning Authority	Suggested Management Focus
Catchment	0.05 - .050	Local property owner	Best Management Practices
Sub-watershed	1 - 10	Local Government	Stream Management & Classification
Watershed	10 - 100	Local, or multi-local	Watershed-based Planning
Sub-basin	100 – 1,000	Local, regional, and State	Basin Planning
Basin	1,000 – 10,000	State, multi-state, federal	Basin Planning

(Schueler, 2003)

Watershed Planning

The Watershed Management Plan (WMP) is intended to benefit communities in the watershed by helping to improve the local economy, increase effectiveness of government, and preserve the environment through comprehensive water resource planning. Watershed planning can benefit the local economy by helping to protect drinking water supply, decrease losses related to floods, and increase property values by providing attractive and safe living and recreation areas. Furthermore, good watershed planning can improve the effectiveness of government through more direct public involvement that earns the trust and support of the community and guarantees that all community interests are treated fairly. The planning effort also helps to ensure that current water quality in the community is preserved and that the community will not suffer significant financial losses due to loss of natural resources.

The planning process is not without some complications as members of watershed communities commonly can have competing desires for how water is used. For example, a large proportion of Morgan County is agricultural with many farming interests. A farmer will view water quality issues differently than will others in the community. However, the interests of that farmer must be taken into consideration if the WMP is to be a benefit to the whole community. Likewise, the homeowner in Mooresville that uses a municipal well for water supply has an interest in clean drinking water that is not polluted from other watershed users. Further complication of the planning process is realized when there are several government jurisdictions with different sets of ordinances and rules for water use. Nonetheless, it is imperative that the planning process formulate a workable WMP that is sensitive to the values and desires of all members of the community and is developed with the input and support of a good cross-section of the community. Input from the farmer, homeowner, government administrator, elected official and others in the community will help to ensure that there is balance and equitable distribution of responsibility for and benefits of good water quality in the watershed.

Watershed planning is especially important to help prevent future water resource problems, preserve watershed functions, and ensure future economic, political, and environmental health.

Many activities throughout the watershed that have an impact on watershed users, but the efforts are not organized, and occasionally are counter-productive and may limit economic growth and value of land. However, a WMP is a start toward a better understanding of community values and watershed processes and can provide guidance toward the betterment of watershed management and living conditions in the community.

Regulatory Context of Watershed Planning

Watershed management has been widely promoted by the Environmental Protection Agency (EPA) and other public and private organizations concerned with water quality. In fact, by developing WMPs, targeted areas become eligible for funding to implement a wide array of water quality related projects. Funding sources include, but are not limited to, the Indiana Department of Environmental Management (IDEM), the Environmental Protection Agency (EPA), the Indiana Department of Natural Resources (IDNR), and the United States Department of Agriculture (USDA).

Watershed planning can also be a response to regulatory interest in impaired water quality in the watershed. Section 303(d) of the Clean Water Act requires states to identify waters that do not, or are not expected to, meet federal water quality standards. States are also required to develop a priority ranking for these waters taking into account the severity of the pollution and state defined designated uses of the waters. For those waters identified as having impaired water quality, the states are required to develop Total Maximum Daily Loads (TMDLs) in order to achieve compliance with federal water quality standards and the Clean Water Act.

The IDEM has identified the main stem of White Lick Creek as having impaired water quality due to elevated levels of pathogens that include *Escherichia coli* (*E. coli*), polychlorinated biphenyls (PCBs), and Mercury. An effective watershed plan can help to address the water quality impairment identified by the IDEM in the Lower White Lick Creek prior to a TMDL study and could preclude the need for a future TMDL effort if proven effective at improving water quality in the watershed. Furthermore, the WMP will help to demonstrate community involvement and commitment to address impaired water quality in the watershed. Currently, a TMDL has not been developed for the Lower White Lick Creek.

Lower White Lick Creek Watershed Management Plan

A WMP is a guiding document that examines the historical and existing water resource issues in a particular watershed and presents specific actions to address those water resource issues based on the values and needs of the community. The intent of the WMP is to provide better living conditions, economic viability, and environmental health benefits for those that reside in the watershed and for communities downstream. Developers of the WMP are interested stakeholders that have investigated prior and existing watershed conditions, considered pollutant pathways, and formulated strategies for implementing specific actions. The WMP document represents the earnest efforts of the community to understand, analyze, and be an integral part of the solution to improve impaired water quality in the watershed. Furthermore, active community involvement in the development of the WMP helps to ensure that there is commitment by the community to implement projects that are identified in the WMP.

This WMP is an extension of ongoing watershed planning efforts in the County. A WMP has been recently developed for the Lambs Creek Watershed in Morgan County that is adjacent to the Lower White Lick Creek Watershed. Interest and concern for water quality issues in the County inspired a desire to develop a WMP for other impaired watersheds in the County. Focus on the Lower White Lick Creek Watershed has been energized by recent fish kills and poorly planned residential, commercial, and industrial development that threaten to decrease already impaired water quality in the watershed. The Morgan County Soil and Water Conservation District (SWCD) submitted an application for grant funds to develop the WMP and received $76,000 through the IDEM Section 319 Program in November 2003. The SWCD retained Christopher B. Burke Engineering, Ltd. (CBBEL) to serve as the Watershed Coordinator for the development of the WMP. The Watershed Coordinator organizes the steering committee, facilitates stakeholder discussion, presents data and information about the WMP to the committee and the public, and drafts the WMP.

The Lower White Lick Creek WMP presents the overall watershed analysis and inventory conducted by CBBEL, the project Steering Committee, and the public, and offers management recommendations for water quality improvement, preservation, and protection. The Lower White Lick Creek WMP meets the requirements of the IDEM updated 2003 “What Needs to be in a Watershed Management Plan” Checklist.

1.2 WATERSHED PARTNERSHIPS

The Morgan County Watershed Initiative (MCWI) is a partnership of concerned citizens dedicated to developing WMPs for Morgan County, communicating a better understanding of human impacts on water quality, and protecting and improving the quality of life in Morgan County through watershed management.

The MCWI formed in 2000 when the Morgan County SWCD began development of a WMP for the White River/Lambs Creek Watershed in west-central Morgan County. Stakeholders in the MCWI included concerned citizens, government officials, and business leaders that were actively involved in the development of the White River/Lambs Creek Watershed Management Plan. Interest in water quality issues generated by the MCWI has helped to raise the profile of watershed management in Morgan County and has inspired current members of the Lower White Lick Creek Steering Committee to continue their involvement in ongoing watershed planning efforts.

The Lower White Lick Creek WMP Steering Committee

A 17-member Steering Committee was formed to guide the development of the Lower White Lick Creek WMP. Members of the Steering Committee include:

- **Emma Alkire**, Morgan County SWCD Board of Supervisors
- **Joe Beikman**, Superintendent, Mooresville Street and Sewer Department
- **Marvin Brethauer**, Indianapolis International Airport
- **Mike Broadstreet**, District Conservationist, Natural Resource Conservation Service
- **Terry Brock**, Morgan County Surveyor
- **Brent Callahan**, Mooresville Parks Department
- **Donna Chastain**, Morgan County Health Department
- **Brian Love,** Town of Brooklyn
- **Julie Mason**, Resource Specialist, Indiana Department of Natural Resources
- **Chris Parker**, Extension Educator, Purdue Cooperative Extension Service
- **Charlene Pugh**, Town of Brooklyn
- **Jeff Quyle**, Morgan County Commissioner
- **Dee Terrell**, Chairman, Morgan County SWCD Board of Supervisors
- **Anna Tossick**, Morgan County SWCD Environmental Educator

- **Joe Tutterow**, Indiana Land Resource Council
- **Becky Waymire**, Mapleturn Utilities
- **Warren Waymire,** Mapleturn Utilities

Throughout the 2-year planning process, quarterly Steering Committee meetings provided a forum for the discussion of the planning process, identification of water quality issues, prioritization of watershed areas, and formulation of specific mitigation activities.

1.3 PUBLIC PARTICIPATION

This Lower White Lick Creek WMP depends on the input and commitment of volunteers to succeed. Education and outreach efforts are a necessary and effective means for interested individuals to voice concerns for or lend support to the WMP. Education and outreach undertaken during the development of the Lower White Lick Creek WMP included 10 presentations to local organizations, 4 general public meetings, a watershed tour, and articles in the "Watershed Walker" published by the Morgan County SWCD. Presentation of the WMP process and development included presentations to the following community groups in the Lower White Lick Creek Watershed. These meetings provided a mechanism to solicit additional public input for the discussion and identification of priority issues of concern among residents in the Lower White Lick Creek Watershed.

Presentations

1. Morgan County SWCD Annual meeting (February 3, 2004)
2. Mooresville Kiwanis (May 18, 2004)
3. Mooresville Optimist Club (June 10, 2004)
4. Mooresville Chamber of Commerce (August 19, 2004)
5. Morgan County Board of Realtors (September 18, 2004)
6. West Central Solid Waste District (October 27, 2004)
7. Upper White River Watershed Alliance (December 9, 2004)
8. Pesticide Applicators (February 10, 2005)
9. Master Gardeners (May 4, 2005)
10. Mooresville Parks Department (May 9, 2005)

Public Meetings

Public Meeting 1: February 24, 2004, Mooresville School District Education Center
Public Meeting 2: September 13, 2004, Brooklyn Park Shelter House
Public Meeting 3: August 2005, to be determined
Public Meeting 4: September 2005, to be determined

The Watershed Walker

The Watershed Walker is a quarterly publication distributed by the Morgan County SWCD that prints articles related to watershed function and processes in Morgan County. Past publications have included information on woodland management, macro-invertebrates, stormwater regulations, proper fertilizer application, septic systems, and riparian corridors. Issues of the Watershed Walker published during the development of this WMP are included in **Appendix 1**.

1.4 DESCRIPTION & HISTORY

Watershed Location

The study area, or Lower White Lick Creek Watershed, that is the subject of this WMP, is a sub-watershed of the Lower White Lick Creek Watershed and consists of four 14-digit hydrologic unit code (HUC) watersheds as shown in **Exhibit 2**. The Lower White Lick Creek Watershed is an 11-digit (05120201150) watershed that encompasses an area of approximately 290 square miles. And in turn, the Lower White Lick Creek Watershed is a sub-watershed of the 8-digit Hydrologic Unit Code (HUC) Upper White River Basin (05120201) in south central Indiana. The Project Area and its four 14-digit watersheds have a combined area of 44 square miles and cover areas within Morgan, Hendricks, and Marion Counties. Municipal communities within the project watershed include the City of Mooresville, Town of Brooklyn, a portion of the Heartland Crossing development, the Tri-County Conservancy District, and a fraction of the Town of Centerton. A listing of watersheds from largest to smallest are listed in **Table 1-2**.

Table 1-2: Watershed Identifiers

Basin	**8-digit HUC Identifier**
Upper White River	05120201
Watershed	**11-digit HUC Identifier**
White Lick Creek	05120201150
Sub-Watersheds	**14-digit HUC Identifier**
Silon Creek	05120201150160
Monical Branch	05120201150180
Mooresville	05120201150130
Orchard Creek	05120201150170

Ecology

Ecosystem type and condition are defined by the natural history, available natural resources, and human activities in an area. For watershed management planning, regional ecosystem classification is a useful way to examine varied information about the physical, chemical, and biological features of a watershed. Ecoregions classify the landscape according to ecosystem type and by the type, quality, and quantity of natural resources that define that ecoregion. Thus, physical, biological, and chemical conditions are expected to be more similar within a specific ecoregion area. Therefore, the planning effort is made more effective and efficient when these ecosystem characteristics are considered.

Ecoregions are defined by physical conditions as determined by geology, physiographic condition, vegetation, climate, soils, land use, wildlife, and hydrology. Omernik and Gallant identify several major ecoregions for Indiana. Ecoregions identified within the Lower White Lick Creek Watershed include a small portion of the Loamy, High Lime Till Plains ecoregion in the north and the Norman Upland ecoregion to the south. Most of the Lower White Lick Creek Watershed is in the Norman Upland ecoregion. The Loamy, High Lime Till Plains ecoregion contains soils that developed from loamy, limy, glacial deposits of Wisconsinan age; these soils typically have natural drainage and natural fertility. Beech forests, oak-sugar maple forests, and elm-ash swamp forests grew on the nearly level terrain. The Norman Upland ecoregion is mostly forested in contrast to the Loamy High Lime Till Plains ecoregion. It is characterized by dissected high hills and knobs, narrow valleys, and medium to high gradient streams. The silt loam soils were derived from loess, siltstone, shale, or sandstone. Originally, oak-hickory forests grew on the uplands and beech forests were found in the valleys. Today, chestnut oak has replaced American chestnut on the well-drained upper slopes; Virginia pine grows on the southern uplands.

Climate

According to Midwest Climate Data Center records, the average winter temperature is 30°F and the average daily minimum temperature is 21°F. The average temperature during the summer is 74°F and the average daily maximum temperature is 85°F. Average annual precipitation in the area is 40.5". Approximately 60%, or 24", typically accumulates between April and September of any given year. The 2-year, 1-hour duration storm event is approximately 1.44". The watershed receives an average seasonal snowfall of 29" and 15 days out of the year have at least 1" of accumulated snow on the ground. Tornadoes, hailstorms, and severe thunderstorms do occur in the area and typically affect the watershed in late spring and early summer.

Land Use

The Lower White Lick Creek Watershed has an area of 44 square miles, or 28,234 acres. Morgan County has an area of 406 square miles, or 259,840 acres. Therefore, the Lower White Lick Creek Watershed drains approximately 9% of Morgan County. Roughly, 5,700 acres of the Lower White Lick Creek Watershed drain portions of Hendricks and Marion Counties. **Table 1-3** presents the acreage and percentage of the watershed area that lies within the three counties. Approximately 246 square miles of the greater (11-digit HUC) White Lick Creek Watershed is upstream from the Lower White Lick Creek Watershed, and contributes a significant amount of water and contaminants to the East Fork of the White Lick Creek and the main stem of the White Lick Creek that pass through the Lower White Lick Creek Watershed.

Table 1-3: Lower White Lick Creek Watershed

County	Acreage	Percent of Project Area
Hendricks	3,587	13
Marion	2,156	8
Morgan	22,491	79
Total	**28,234**	**100**

(USGS, 1999)

The land use in the watershed is composed of predominantly agriculture, forest, and small to medium sized urban communities. County population density is 169 residents per square mile and total population in 2003 was 68,656. Projected population estimates indicate that the County will grow to 71,862 by 2010. Currently, Morgan County is one of the fastest developing counties in Indiana, and ranks 10th in overall growth rate for Indiana between 1990 and 2000.

Land use by 14-digit watershed is presented in **Table 1-4**. Dominant land use categories are Pasture and crop, deciduous forest, and low-intensity residential development as shown in **Exhibit 3**.

Table 1-4: Land Use by 14-Digit HUC Watershed (acres)

Land Use Description	Mooresville	Monical Branch	Orchard Creek	Silon Creek	Total Acres	Percent of Total
Open Water	69.0	79.4	60.3	19.2	**227.9**	**0.81**
Low Intensity Residential	229.2	330.3	253.2	912.4	**1725.0**	**6.13**
High Intensity Residential	9.0	24.1	7.6	63.9	**104.5**	**0.37**
Commercial/Industrial/ Transportation	106.8	44.5	56.0	129.7	**336.9**	**1.20**
Quarries/ Gravel Pits	15.3	---	---	---	**15.3**	**0.05**
Transitional	---	97.2	---	---	**97.2**	**0.35**
Deciduous Forest	451.0	2275.2	1009.1	797.2	**4532.5**	**16.10**
Evergreen Forest	1.4	4.3	1.6	1.0	**8.3**	**0.03**
Mixed Forest	0.6	---	0.4	0.7	**1.6**	**0.01**
Pasture/Hay	1052.1	1694.7	3728.9	3391.0	**9866.6**	**35.06**
Row Crops	976.4	2808.9	3365.0	3689.4	**10839.8**	**38.52**
Urban/Recreational Grasses	58.5	58.3	---	124.2	**240.9**	**0.86**
Woody Wetlands	26.2	36.9	44.4	34.0	**141.4**	**0.50**
Emergent Herbaceous Wetlands	0.6	3.7	1.8	0.2	**6.3**	**0.02**
Total Acres in HUC-14*	**2996.0**	**7457.5**	**8528.2**	**9162.6**	**28144.3**	**100.00**

* Total acreage differs slightly than that calculated by HUC areas as a whole due to data processing, and rounding error.
(USGS, 1999)

That portion of the Lower White Lick Creek Watershed area in Hendricks County is primarily nature preserve and wetland mitigation land that is owned and managed by the Indianapolis International Airport (IIA). Additionally, since 1999, there has been significant new development in and around the Project Area. Unfortunately, more recent land use data are not readily available; however, it is important to note that new development has reduced the total acreage of agricultural areas in the Lower White Lick Creek Watershed.

Soils

According to the USGS National Water Quality Assessment Program Report for the White River, the Lower White Lick Creek Watershed is composed of two primary hydro-geomorphic strata, the till plain and the bedrock upland. Glacial Till is drift material composed of an unorganized and varied mixture of clay, sand, pebbles, cobbles, and boulders. Glacial till plain covers most of the watershed with topography that is flat to gently rolling. Historic deposits consist of buried pre-Wisconsinian till overlying Wisconsinian till at the surface and range in depth between 50-400 feet. Bedrock uplands make up the southern portion of the watershed and consist of relatively resistant siltstone, sandstone, limestone, and shale.

The Morgan County Soil Survey identifies seven general soil types in the County and these are listed in **Table 1-5** along with information about the extent of the soil type in the County and its potential use.

Table 1-5: Soil Regions of Morgan County

Region	Soil Region Description	Percent in Morgan County	Soil Complexes	Potential Use
1	Deep, nearly level, well-drained to somewhat poorly drained soils on floodplains and low terraces	20%	Wakeland-Banlic-Wilbur Genesee-Shoals	Good for crop and pasture activities Poor for residential/urban development
2	Deep, nearly level and gently sloping, very poorly drained to well-drained soils on outwash plains, terraces, lakebeds, and uplands	16%	Rensselaer-Whitaker-Martinsville Patton-Whitaker Crosby-Brookston	Good for crop and pasture activities Poor for residential/urban
3	Deep, nearly level to very steep, well-drained to somewhat poorly drained soils on uplands	25%	Miami-Crosby Miami-Fincastle-Xenia	Good for cropland/pasture & residential/urban development
4	Deep and moderately deep over sand and gravel, nearly level to moderately steep, well-drained soils on outwash plains, terraces, and uplands	5%	Fox-Ockley Princeton	Fair for crops Good for residential/urban development
5	Deep, nearly level to very steep, well-drained soils on uplands,outwash plains, terraces, and moraines	8%	Alford-Grayford Alford-Hickory Parke-Chetwynd-Pike	Good for crops Fair for residential/urban
6	Deep, nearly level to very steep, well-drained to poorly drained soils on uplands	15%	Hickory-Bedford Hickory-Cincinnati-Ava Vigo-Ava-Cincinnati	Fair for crops Poor for residential/urban
7	Moderately deep and deep, gently sloping to very steep, well-drained soils on uplands	11%	Berks-Gilpin-Zanesville	Poor for crops and residential/urban

(Morgan County Soil Survey, 1978)

According to soil characteristics, approximately 62% of Morgan County is unsuitable for residential or urban development, while most soil regions will support cropland, livestock, and pasture activities.

Portions of the Lower White Lick Creek Watershed have a combination of non-cohesive soil types and steep slopes. These areas are potentially a significant source of sediment to the valley floodplains and stream system if they become exposed to rain, wind, or frost erosion processes. The Natural Resources Conservation Service (NRCS) classifies these areas as Highly Erodible Land (HEL) areas. These areas have not been mapped yet for Morgan County by the NRCS. Though these areas are not presented in this WMP, portions of the Lower White Lick Creek Watershed exhibit non-cohesive soils in steep regions that could be classified as HEL and should receive greater management attention than other areas that are less susceptible to surface erosion.

Topography

The topography of Morgan County is complex, with a range of relief from 970 feet above sea level to 550 feet above sea level. The northern portion of the County, which includes much of the Lower White Lick Creek Watershed, is nearly level with some gentle rolling hills. The central and southern parts of the County (a fraction of the southern portion of the project area) vary more in elevation than the northern part of the watershed. Some locations have bluffs with sharp drops of as much as 250 feet from the ridge tops to the bottomlands; others have broad, flat floodplains that spread out along White Lick Creek and the White River.

Hydrology

The Lower White Lick Creek Watershed has a drainage area of 44 square miles, or 28,144 acres, and has approximately 48 miles of perennial streams. The extent and length of artificial channels in the Lower White Lick Creek Watershed are not measured in this WMP; however, the prevalence of agriculture and soil conditions throughout the County suggests that drainage canals may contribute a substantial amount to the overall drainage density of the watershed. Drainage density of a watershed influences how efficient an area may be in collecting and conveying runoff in the watershed, and has implications for peak discharge, sedimentation, and transport of nutrients and pathogens. Major tributaries include Silon Creek, Orchard Creek, and Monical Branch as shown in **Exhibit 4**. The West Fork of White Lick Creek meets the East Fork of White Lick Creek just south of the Town of Mooresville in Morgan County, and forms the main stem of White Lick Creek. White Lick Creek then flows south, through the Town of Brooklyn, where it eventually drains to the White River south and east of the Town of Centerton.

The drainage network of the Lower White Lick Creek Watershed includes stream channels of 1^{st}, 2^{nd}, and 3^{rd} order based on the Strahler classification system. First order channels are headwater streams, second order channels are created at the junction of two 1^{st} order stream; 3^{rd} order streams are, likewise, created by the convergence of two 2^{nd} order streams. Channel materials are similar to the source soils described above. Channel types and forms in the County vary between straight artificial agricultural drainage ditches, meandering, and braided channels. There is evidence in aerial photos that the course of White Lick Creek and the White River has varied significantly in the past. The number and extent of oxbow wetlands and relic cut-offs suggest that these waterways may alter course unexpectedly.

Dam Impoundments

There are 9 dams in the Lower White Lick Creek Watershed registered with the Indiana Department of Natural Resources – Division of Dams. Together the dams have more than 400 acre-feet of storage, more than 43 acres of surface area, and more than 2 square miles of drainage area. Dams in Indiana must be registered with the IDNR if the contributing watershed to the dam is greater than 1 square mile, has a dam embankment greater than 20-feet high, or impounds more than 100 acre-feet of water. A dam must also be registered if it poses a high to significantly high hazard to downstream communities. Locations of the dams in the Lower White Lick Creek Watershed are presented in **Exhibit 5.** Dam impoundments can help to keep some contaminants from reaching waterways in the study area; particularly fine sediments and associated nutrients and pesticides that settle out in the relatively calm waters behind dams. However, these pollutants and contaminants are mere stored in these impounded areas and may eventually be released into the waterways at a later date.

Land Ownership

Most of the Lower White Lick Creek Watershed is in private ownership. Less than 1% of the watershed area is designated as public open space. The largest public landowner is the Indianapolis International Airport (IIA) that owns approximately 1,890 acres within and adjacent to the Lower White Lick Creek Watershed. Outside of the IIA holdings, there are no major local, state, or federal land holdings in the Lower White Lick Creek Watershed.

Cultural Resources

Human occupation of the Lower White Lick Creek Watershed is estimated to have occurred as early as 11,000 years ago. Early Native Americans established settlements and transportation routes through the area, leaving behind a rich and amazing variety of cultural artifacts. Native peoples residing in present-day Indiana in the more recent past were the Miami, Delaware and Shawnee.

The period of initial occupation by Anglo-American settlers began during the years between Indiana statehood in 1816 and the cession of lands comprising southern Indiana by the Miami Indians in 1818. The first public sales of land in the area that would become Morgan County occurred in 1820. The county was established as a legal entity in 1822. Early platted villages within the Watershed include Martinsville, the Morgan County seat, platted in 1822; Monrovia (1834); Centerton (1854); and Hall (1851-52). The majority of early settlers migrated into southern Indiana from Appalachia, bringing with them cultural traditions of the Upland South: speech and agricultural patterns, food routes, architecture, even political ideology. During this period of initial settlement (1816-1853), pioneers established home sites and communities along White River and its creek tributaries. They felled the native trees—poplar, walnut, white oak, hickory, beech, maple and other varieties—and cleared the land for farms on which were raised corn and livestock, especially hogs. The bluffs were used for grazing.

Pork packing was a major early industry. Flatboats loaded with pork and grain were regularly sent down White River to New Orleans. Other pioneer-era industries dependent on the area's natural resources included saw and gristmills, brick making, and the quarrying of limestone for bridge abutments and building foundations.

The completion of the railroad through Martinsville in 1853, and through Mooresville—the largest town in the northern part of Morgan County—in the 1860s, boosted the county's agricultural economy by providing a link to distant markets. Pre-Civil War-era prosperity and an increasing population that demanded more public services and structures—churches, schools, commercial business, professional services—is reflected in a number of significant historic properties that mark the mid-nineteenth-century. These include a number of rural one-room schoolhouses in each sub-watershed, as well as fine brick houses and the commercial district in Monrovia.

Due in large part to the coming of the railroads, Morgan County experienced a period of growth and maturity between 1853 and 1910. No longer solely reliant on fulfilling its own needs, residents turned to outside sources for necessary and desired goods such as building supplies, household goods, farm implements, clothing and machinery. Improved roads were necessary to transport goods such as these from the railroad stations in Martinsville and Mooresville. Several corporate organizations, such as the Monrovia and Hall Gravel Road Company, were organized. Improved roads brought a second generation of bridges, mostly iron trusses that replaced wood covered bridges.

The years between 1853 and 1910 saw a number of families establish large farming enterprises in areas of rich, sandy loam in the White River bottoms and in the northwest portion of the county. This area had been a natural marsh before being drained between 1875-1916 with the construction of Lake Ditch and a number of smaller ditches.

Beginning about 1895, Morgan County entered a period of specialized industry dependent on its rich variety and abundance of natural resources. A number of unique businesses found a home in the White River Watershed. In Centerton and Brooklyn, clay and shale were mined and used for the production of brick and tile.

With increased mobility using the Interurban and privately owned motorcars, Morgan County waterways—especially White Lick Creek and White River—became popular sites for recreation. Private clubs included Rettun Lodge, owned by the Nutter family, and the High Rock Cabin, both located on White River at High Rock. Numerous fishing camps along the sandy banks of the river along the current SR 67, such as Kirkwood and Idle Hours, were available to less prosperous residents.

Major floods in 1875 and 1913 saw Morgan County's creeks and White River raise to unprecedented levels. The flood of 1913 was a repeat of the earlier tragedy. After nearly 48 hours of continuous rain on March 24-25, 1913, the White River escaped its banks at Centerton and swept into Martinsville. Estimated to be a mile in width in some places, the swollen river destroyed the rail and Interurban lines, washed out bridges and downed telephone lines. A less devastating flood occurred again in 1930. In hopes of preventing still more disasters, the Army Corps of Engineers constructed the existing levee on the east side of White River north of SR 39 in the mid-1950s.

From the period of Native American occupation to the present, the White River Watershed is an area rich with significant cultural resources. It is the hope of the professional and community members of the Morgan County White River Watershed Initiative that these resources will continue to be respected, researched, preserved, and promoted.

Endangered, Threatened, and Rare Species

In addition to a wide variety of native tree species, the Lower White Lick Creek Watershed is home to several unique plant and animal species. **Table 1-6** lists both the state and federal species that might be found within Hendricks, Marion, and Morgan Counties and are classified as endangered, threatened, or rare. No readily available information is known about current populations and locations of these endangered, threatened and rare species.

Table 1-6: Endangered, Threatened, and Rare Species for Morgan County

Species	Common Name	Scientific Name	State Rank	Federal Rank
Vascular Plants	Pink Thoroughwort	*Eupatorium incarnatum*	ST	NL
	Eastern White Pine	*Pinus strobus*	SR	NL
	Purple Flowering Raspberry	*Rubus odoratus*	ST	NL
	Tufted Hairgrass	*Deschampsia cespitosa*	SR	NL
	Butternut	*Juglans cinerea*	WL	NL
	Virginia Bunchflower	*Melanthium virginicum*	SE	NL
	Wolf Bluegrass	*Poa wolfii*	SR	NL
	Running Buffalo Clover	*Trifolium stoloniferum*	SE	LE
	Brook-Pimpernell	*Veronica anagallis-aquaticus*	ST	NL
Mussels	Northern Riffleshell	*Epioblasma torulosa rangiana*	SE	LE
	Round Hickorynut	*Obovaria subrotunda*	SSC	NL
	Clubshell	*Pleurobema clava*	SE	LE
	Pyramid Pigtoe	*Pleurobema rubrum*	SE	NL
	Rabbitsfoot	*Qaudrula cylindrical cylindrica*	SE	NL
	Snuffbox	*Epioblasma triquetra*	SE	NL
	Ellipse	*Venustaconcha ellipsiformis*	SSC	NL
	Little Spectaclecase	*Villosa lienosa*	SSC	NL
Fish	Gilt Darter	*Percina evides*	SE	NL
	Eastern Sand Darter	*Ammocrypta pellucida*	SSC	NL
Reptiles	Kirtland's Snake	*Clonophis kirtlandii*	SE	NL
	Timber Rattlesnake	*Crotalus horridus*	SE	NL
	Alligator Snapping Turtle	*Macrochelys temminckii*	SE	NL
	Eastern Massasauga	*Sistrurus catenatus*	SE	NL
	Spotted Turtle	*Clemmys guttata*	SE	NL
	Blanding's Turtle	*Emydoidea blandingii*	SE	NL
	Butler's Garter Snake	*Thamnophis butleri*	SE	NL
Birds	Sharp-Shinned Hawk	*Accipiter striatus*	SSC	NL
	Bachman's Sparrow	*Aimophila aestivalis*	SE	NL
	Upland Sandpiper	*Bartramia longicauda*	SE	NL
	Red Shouldered Hawk	*Buteo lineatus*	SSC	NL
	Broad Winged Hawk	*Buteo platypterus*	SSC	NL
	Cerulean Warbler	*Dendroica cerulea*	SSC	NL
	Bald Eagle	*Haliaeetus leucocephalus*	SE	LE
	Worm Eating Warbler	*Helmitheros vermivorum*	SSC	NL
	Loggerhead Shrike	*Lanius ludovicianus*	SE	NL
	Osprey	*Pandion haliaetus*	SE	NL
	Bewick's Wren	*Thryomanes bewickii*	SE	NL
	Hooded Warbler	*Wilsonia citrina*	SSC	NL
	Upland Sandpiper	*Bartramia longicauda*	SE	NL
	Sedge Wren	*Cistothorus platensis*	SE	NL
	American Bittern	*Botaurus lentiginosus*	SE	NL
	Peregrine Falcon	*Falco peregrinus*	SE	E(S/A)

Species	Common Name	Scientific Name	State Rank	Federal Rank
	Least Bittern	*Ixobrychus exilis*	SE	NL
	Black and White Warbler	*Mniotilta varia*	SSC	NL
	King Rail	*Rallus elegans*	SE	NL
Mammals	Northern River Otter	*Lontra canadensis*	SE	NL
	Bobcat	*Lynx rufus*	SE	NL
	American Badger	*Taxidea taxus*	SE	NL
	Indiana Bat	*Myotis sodalis*	SE	LE
	Evening Bat	*Nycticeius humeralis*	SE	NL

State Rank: SE=endangered, SR=rare, ST=threatened, SSC=special concern, WL= watch list, Federal Rank: LE=endangered, LT= Threatened, E(S/A)=appearance similar to LE or LT species, NL=not listed.
(IDNR, 2005)

Wetlands
Since 1954, the U.S. Fish and Wildlife Service has maintained an inventory of wetlands in the United States. Since beginning the National Wetland Inventory (NWI), wetland identification and role in society has undergone considerable change; their characteristics, importance to water resources, and natural aesthetic and biological values have become better defined and more widely known. State and Federal legislation enacted after the Clean Water Act was passed in 1972, and amended in 1977, now protects wetlands resources across the United States.

The NWI defines wetlands as, "…lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly un-drained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of the year."

Wetlands in the Lower White Lick Creek Watershed include areas classified as Riverine, Lacustrine, or Palustrine wetland systems. Riverine wetland systems occur in river and stream lowlands and floodplains. Lacutrine wetland systems are characterized by lake and/or pond systems with perennial and deep-water habitat. Palustrine wetland systems are periodically saturated areas with water tolerant species of trees, shrubs, and a variety of wetland emergent vegetation and hydric soils. Three hundred and eighty wetlands are identified in the NWI for the Lower White Lick Creek Watershed and cover approximately 1,206 acres (1.88 square miles) and are presented in **Exhibit 6**. The distribution of the wetlands in the watershed is diffuse, and most are classified as Palustrine, with the exception of 2 that are Lacustrine. NWI wetland maps often do not indicate all wetlands that may exist in an area. Given the prevalence of poorly drained soils in many parts of the watershed, the number of actual wetlands may be underestimated in the Lower White Lick Creek Watershed.

2.0 IDENTIFYING WATER QUALITY PROBLEMS & CAUSES

As part of the watershed planning process, an inventory and assessment must be made of prior water quality studies in the watershed. Examination of previous work may show that data already gathered is sufficient for determining the magnitude and extent of water quality conditions, or it may indicate that additional studies are needed to characterize the water quality problems. In either case, assessing water quality information that has already been completed is part of the initial process of building a WMP and will help to guide the identification of water quality problems and links to pollution sources in the watershed. The following section provides a summary of past and current water quality monitoring and assessments.

2.1 STAKEHOLDER CONCERNS

A watershed tour was conducted on January 9, 2004 that included members of the Steering Committee and served as a forum to directly observe and discuss existing conditions in the watershed. Following the tour the Steering Committee discussed their observations and identified the following issues as preliminary water quality concerns in the Lower White Lick Creek Watershed. **Table 2-1** summarizes the stakeholder concerns gathered during the tour.

Table 2-1: Stakeholder Concerns

Agricultural Lands
• nutrient/pesticide leaching in sandy soils
• nutrient/pesticide runoff
• manure runoff from pasturelands
• streambank erosion
• lack of vegetated buffers between croplands and streams
Developments/Developing Lands
• large lot development
• filling of the floodplain
• impervious surfaces
• erosion/sedimentation from construction sites
Human Waste Disposal
• failing septic systems
• straight pipe discharge
• illicit connections to agricultural tile drains
• small package plants in the Orchard Creek watershed
• Mooresville and Brooklyn WWTPs
Indianapolis International Airport Activities
• mitigated property in the East Fork watershed
• IIA airfield expansion project

Industrial Clean-up: Dumps/Salvage Yards
• roadside dumping
• proximity of salvage yards to White Lick Creek (Brooklyn)
• abandoned salvage yard in Brooklyn
Household & Yard Waste
• pond maintenance
• septic system operation and maintenance
• landscaping/gardening practices
• fertilizers
• pesticides
• stormwater management
Commercial/Industrial Properties
• 2 golf courses
• 2 shale mining operations (Monical Branch watershed)

2.2 WATER QUALITY BASELINE STUDIES

National Water Quality Assessment, White River, 1992-1996

The National Water Quality Assessment (NAWQA) Program is the primary source for long-term, nationwide information on water-quality conditions and ecosystem health. In more than 50 major river basins and aquifers across the nation, USGS scientists collect and assess information on water chemistry, hydrology, land use, stream habitat, and aquatic life. Each NAWQA assessment adheres to a nationally consistent study design and methods of sampling and analysis, so that water-quality conditions in a specific locality or watershed can be compared to those in other geographic regions. The consistent study design and methods also allow contaminants such as pesticides, nutrients, industrial and petroleum-based compounds, trace metals, and aquatic ecology to be assessed on a comprehensive national basis. This study presents major findings that emerged between 1992 and 1996 from the water-quality assessment of the White River Basin Study Unit and relates these findings to water-quality issues of regional and national concern.

Results of the study indicate that at urban and rural locations throughout the White River Watershed, including the White Lick Creek Watershed, pesticide concentrations were among the highest recorded in the nation. Though most samples recorded concentrations below federal guidelines, there were 25 different pesticides, or pesticide degradation products, in at least 5% of all samples. Fourteen different pesticides were detected in 94 monitoring wells throughout the watershed; though no sample exceeded federal guidelines for drinking water contamination. The most common pesticides recorded were atrazine, alachlor, and cyanazine. Nitrate concentrations ranged between 2-6 mg/L, which is higher than most other sample sites in the United States. Few of the samples exceeded the federal drinking water standard of 10 mg/L. Shallow aquifer well sources appear to be the most susceptible to contamination. Seventeen percent of shallow aquifer wells monitored showed an excess of 10 mg/L of nitrate concentration in the water. Water tested in urban areas showed elevated concentrations of trace metals and organic compounds. A Fish Consumption Advisory (FCA) warning exists for many fish species in the rivers and waterways of the watershed. Though no federal drinking water standard was exceeded during testing, more than half of all groundwater wells in urban areas had volatile organic compounds, primarily Chloroform. Fish community diversity and health was poor despite fair to good habitat conditions, suggesting non-habitat stressors were depressing population diversity and abundance.

IDEM & IDNR Watershed Biotic & Water Quality Assessments

1997 Preliminary Appraisal of the Biological Integrity of the East Fork White Lick Creek

Results of the assessment indicate that fish communities and habitat in the main stem of the East Fork White Lick Creek is of good quality; however, the headwaters are of poorer quality. The single headwater stream was rated as “poor,” the second site (upstream from the IIA) was rated as “fair,” and the lower three sites (below IIA) were rated as “good.” Because the sites downstream of the IIA were indicated “good” conditions, the authors concluded that airport activities were not causing a decline in the biological integrity of the East Fork White Lick Creek. The study does not discuss sources of water quality problems in the headwaters. The assessment states that top-level carnivore species seem to be generally lacking in the creek indicating that the stream is experiencing stress. It also states that pioneer, tolerant species made up a higher proportion of the fish community in the headwaters indicating local, environmental stress. Furthermore, the authors warned that future habitat alterations could have detrimental downstream impacts to in-stream biological communities.

IDNR 2001 Fisheries Survey of White Lick Creek

In 2001, the Fisheries Section of the IDNR conducted a fish survey of four sites within the 11-digit HUC White Lick Creek Watershed. Results indicate that habitat scores ranged from “poor” to “very good.” White Lick Creek has average species diversity compared to other major streams in Indiana, although the overall species diversity was better than the state average. The abundance of species intolerant of poor water quality such as the long-ear sunfish, northern hog sucker, and various species of red-horse suggests that water quality is “pretty good.” With the exception of RM 11.4, which has a wide riparian corridor, the remaining sampled reaches had minimal or no riparian zone.

The authors recognize that fish communities in the White Lick Creek appear to be doing well and indicate good water quality conditions; however, they state habitat improvements can be made at all stations with the expansion of riparian zones. Furthermore, the authors suggest that the water quality of White Lick Creek is in jeopardy by development occurring in the area that could bring increases in sedimentation associated with construction of residential and commercial structures.

Indiana List of Impaired Waters (303(d))

Section 303(d) of the Clean Water Act (CWA) requires that surface water bodies not meeting or not expected to meet water quality standards after the implementation of regulatory controls (NPDES permits) be compiled and listed as “impaired waters” by IDEM. The 2004 statewide list of 303(d) impaired streams identifies stream segments that are impaired and the pollutant(s) responsible for the impairment. Indiana designated impaired waterways in the Lower White Lick Creek Watershed for 2004 are listed in **Table 2-2.** **Exhibit 7** identifies the locations of 303(d) listed streams within the Lower White Lick Creek Watershed.

Table 2-2: 2004 303(d) Listed Streams in the Lower White Lick Creek Watershed

303(d) #	Major Basin	14 Digit Hydrologic Unit Code	County	Waterbody Name	Parameters of Concern
163	W. Fork White River	05120201150130	Hendricks/ Morgan	White Lick Creek - Mooresville	FCA* for PCBs and Mercury
163	W. Fork White River	05120201150130	Morgan	White Lick Creek - Mooresville	*E. coli*
109	W. Fork White River	05120201150160	Hendricks	East Fork White Lick Creek	FCA for PCBs
109	W. Fork White River	05120201150160	Morgan	East Fork White Lick Creek – Silon Creek	*E. coli*
109	W. Fork White River	05120201150160	Morgan	East Fork White Lick Creek	*E. coli*
163	W. Fork White River	05120201150170	Hendricks/ Morgan	White Lick Creek	FCA for PCBs and Mercury
163	W. Fork White River	05120201150170	Hendricks/ Morgan	White Lick Creek	*E. coli*
163	W. Fork White River	05120201150180	Morgan	White Lick Creek	*E. coli*
163	W. Fork White River	05120201150180	Hendricks/ Morgan	White Lick Creek	FCA for PCBs and Mercury

*FCA: Fish Consumption Advisory
PCB: Polychlorinated Biphenyls
(IDEM, 2004)

Fish Consumption Advisories

Since 1972, three agencies have collaborated to create the Indiana Fish Advisory and include the IDEM, the IDNR, and the Indiana State Department of Health (ISDH). Authorities from these agencies coordinate and analyze results of statewide fish monitoring data on an annual basis to refine and define a current statewide Fish Consumption Advisory (FCA). Currently, all sub-watersheds of the Lower White Lick Creek Watershed are listed as having a mercury and PCB advisory for all fish.

Indiana Integrated Water Quality Monitoring and Assessment Report, 2004

Section 305(b) of the Clean Water Act requires states to prepare and submit to the EPA a biennial assessment report of state water resources. The IDEM through the Office of Water Management (OWM) prepared the Indiana 2004 Water Quality Report (305(b) Report) to meet this reporting requirement. Water quality conditions listed by the 305(b) report for White Lick Creek are listed in **Table 2-3**. Notable impairments in the Lower White Lick Creek Watershed include *E. coli*, PCBs, and Mercury.

Table 2-3: IDEM's 2004 305(b) Water Quality Report

Lower White Lick Creek Watersheds	Aquatic Life	Drinking Supply	Fish Consumption Advisory	Contact Recreation
Mooresville (05120201150130)	F	N/A	P	N
Orchard Creek (05120201150170)	F	N/A	P	F
Monical Branch (05120201150180)	F	N/A	P	P
Silon Creek (05120201150160)	F	N/A	P	F

F=Full support, P=Partial support, N=Non-supporting, X=Not Assessed, N/A=Not Applicable
(IDEM, 2004)

The most significant impairments to water quality were identified by the IDEM were found in the Mooresville sub-watershed and the main stem of White Lick Creek. Only the Mooresville sub-watershed shows non-support for full contact recreation. Causes and sources of these pollutants were not specifically identified in previous monitoring studies.

2003-2005 CBBEL Chemical Monitoring

In an effort to better understand and confirm local water quality conditions, CBBEL, Commonwealth Bio-monitoring, Inc., and the ISDH developed a partnership to conduct water quality monitoring that included both chemical and biological monitoring.

CBBEL collected water samples from 12 monitoring locations within the Lower White Lick Creek Watershed and submitted samples to the ISDH lab for chemical analysis. Monitoring parameters were selected to characterize pollutants generally associated with non-point sources of pollution and were limited by the analytical capabilities of the ISDH lab. Chemical parameters tested for included pH, temperature, dissolved oxygen, turbidity, specific conductance, *E. coli*, total Kjeldahl nitrogen, total phosphorous, and total organic carbon (TOC). Alkalinity-acidity (pH), temperature, and dissolved oxygen were analyzed in the field with field equipment. Indiana State Board of Health Laboratory in Indianapolis analyzed those remaining parameters that could not be measured effectively in the field. **Exhibit 8** illustrates the monitoring locations for this project and **Table 2-4** identifies the precise location for all sites. All raw data for the chemical and biological monitoring effort are included in **Appendices 2 and 3**.

Table 2-4: Monitoring Station Locations

Site ID #	Reach Name	Location
Site 1	East Fork White Lick Creek	Bridge at 700S in Hendricks Co.
Site 2	East Fork, White Lick Creek	Footbridge in Mooresville's Pioneer Park
Site 3	East Fork White Lick Creek	End of Carol Lane
Site 4	West Fork White Lick Creek	Bridge at New Castle Road west of Mooresville
Site 5	West Fork White Lick Creek	Bridge at SR42 west of Mooresville
Site 6	West Fork White Lick Creek	Bridge on SR67 south of Mooresville
Site 7	Monical Branch	Merriman Rd. bridge west of SR 67
Site 8	Monical Branch	Bridge at Country Club Rd. north of Brooklyn
Site 9	White Lick Creek	Centerton Rd. bridge east of SR 67
Site 10	White Lick Creek	Wetzel Rd. east of Country Club Rd.
Site 11	Orchard Creek	Bridge at Rooker Rd. in Mooresville
Site 12	Orchard Creek	Bridge at SR 144 east of Mooresville

Oxygen Consuming Wastes

Since maintaining sufficient levels of dissolved oxygen in a water body is critical to the survival of most forms of aquatic life, evaluating oxygen-consuming wastes in a river or stream is central to diagnosing the health of a river system. Pollutants associated with oxygen consuming wastes are typically composed of either decomposing organic matter or chemicals that bind with available in stream oxygen to reduce the available concentrations of dissolved oxygen in the water column. Organic causes of oxygen consuming wastes are measured as biochemical oxygen demand (BOD) and chemical causes of oxygen consuming wastes are measured as chemical oxygen demand (COD); however, the concentration of dissolved oxygen in a water body is used as a common indicator of the general health of an aquatic ecosystem.

Chapter 327 IAC Section 6(b)(3) states that concentrations of dissolved oxygen shall average at least five milligrams per liter per calendar day and shall not be less than four milligrams per liter at any time. A number of factors affect dissolved oxygen concentrations. Physical conditions, such as lower water temperatures generally allow for retention of higher dissolved oxygen concentrations. In addition, higher dissolved oxygen concentrations can be naturally, or artificially, produced by turbulent actions, such as by in stream riffles or by the cascading effect of a water body spilling over a dam, which inject air into surface waters. Low dissolved oxygen levels tend to occur more often in warmer, slow moving waters. In general, the lowest dissolved oxygen concentrations occur during the warmest summer months and particularly during low flow periods.

As shown in **Table 2-5**, monitoring results indicate that Site #2 (White Lick Creek at the bridge at Old SR 67 northeast of Mooresville), Site #5 (Tributary to White Lick Creek at the bridge at SR42 west of Mooresville), and Site #1 (White Lick Creek at the bridge at 700S in Hendricks Co) experienced the lowest dissolved oxygen levels of the twelve sampling locations.

Table 2-5: Dissolved Oxygen at Monitoring Sites

Site Number	Average mg/L	Median Mg/L	% of Samples Exceeding WQS	Priority Rank
Site # 1	8.12	8.05	11.1	**10**
Site # 2	8.58	8.33	16.6	**12**
Site # 3	8.77	8.74	0	**1**
Site # 4	8.77	8.4	5.5	**6**
Site # 5	9.23	8.8	11.1	**11**
Site # 6	8.6	7.6	5.5	**7**
Site # 7	8.35	7.9	0	**4**
Site # 8	8.5	8.0	0	**2**
Site # 9	8.4	8.15	0	**3**
Site # 10	8.72	8.43	5.5	**8**
Site # 11	8.47	8.84	5.5	**9**
Site # 12	9.03	9.76	5.5	**5**

(1 = Lowest Priority and 12 = Greatest Priority)

Diurnal fluctuations of oxygen in the water column due to conditions of nutrient enrichment could be contributing to the low dissolved oxygen concentrations. Although the process of photosynthesis in plants and algae produces a large volume of oxygen during periods of daylight, respiration by algae during the nighttime hours absorbs more oxygen than the water column can maintain, resulting in times when dissolved oxygen concentrations are significantly reduced or depleted. This situation can be intensified in hot weather and low flow conditions due to the reduced capacity of water to retain dissolved oxygen.

The typical sources of pollution that contribute to low dissolved oxygen levels include inadequate wastewater treatment of wastewater from improperly functioning septic systems or wastewater treatment plants, manure runoff associated with land applications, and other sources of organic waste.

Table 2-6 below identifies examples of dissolved oxygen concentration in natural waterways and classifications associated with each range of concentrations. Dissolved oxygen concentrations below 3.0 mg/L are considered to be stressful to fish and levels below 2mg/L will not typically support fish.

Table 2-6: Dissolved Oxygen Concentrations and Waterway Classification

Dissolved Oxygen Concentration (mg/L)	Waterway Classification
5.4 to 14.8	Typical Range of healthy waterway
5.0 to 6.0	Optimal Range for Aquatic Growth
0.1 to 5.0	Low Range in Natural Waterways

Phosphorus

Non-point source discharges are the major sources of phosphorus in most watersheds. Phosphorus can be present as organic matter (living or dead organisms and excreted organic material) and can be either dissolved or suspended in the water column. Phosphorus may also occur in inorganic compounds released from various minerals, fertilizers, or detergents that may also be either dissolved or suspended in the water column. Phosphorus is the primary nutrient associated with production of algae and macrophytes (plants) in aquatic environments, as it is generally the nutrient in shortest supply in these systems.

Elevated phosphorus concentrations are a cause of pollution in the Lower White Lick Creek Watershed. In the absence of a specific surface water quality standard for phosphorus, results from 2002 monitoring project were compared to the results of a statistically based study of the West Fork White River Basin study completed by the IDEM in 1998. The “1996 Probabilistic Monitoring Program Assessment of the West Fork White River and the Patoka River Basins” was a probabilistic monitoring study that consisted of a one-time sampling of 27 randomly chosen sites within the West Fork White River watershed designed to gain an understanding of ambient water quality during low flow conditions in the basin. The data from this study were statistically evaluated to create a classification metric based on quartile ranges (IDEM, 1998). The classifications were high, upper ambient, ambient, lower ambient, and low and summary statistics were developed appropriate for establishing metrics for each eight digit HUC watershed within the basin, as well as for the compiled dataset from all seven eight digit HUC watersheds.

Monitoring results were compared to the summary statistics and classification metrics for White River tributary streams from the IDEM 1996 study. An evaluation of the 1996 study’s summary statistics indicated that the average concentration of phosphorus for samples collected in the West Fork White River watershed was 0.23 mg/L, while the median concentration of phosphorus was 0.14 mg/L. Concentrations of phosphorus exceeding 0.35 mg/L were considered to be “high”.

As illustrated in **Table 2-7**, monitoring locations were prioritized according to the level of phosphorus impairment, which was judged by the high percentage of samples that exceeded the “High” classification metric as compared to the IDEM’s 1996 study of the West Fork White River. For sites that did not report a sample that exceeded the High classification, rankings were based on which sites maintained the highest average phosphorus results. This ranking is independent of the results from other parameters.

Table 2-7: Priority Ranking for Total Phosphorus

Site #	Average mg/L	Median mg/L	% of Samples Exceeding “High”	Priority Ranking
Site # 1	0.23	0.2	6	**12**
Site # 2	0.16	0.16	6	**11**
Site # 3	0.128	0.13	0	**6**
Site # 4	0.15	0.14	0	**10**
Site # 5	0.04	0.03	0	**3**
Site # 6	0.137	0.13	0	**9**
Site # 7	0.03	0.03	0	**1**
Site # 8	0.031	0.03	0	**2**
Site # 9	0.131	0.12	0	**7**
Site # 10	0.135	0.14	0	**8**

Site #	Average mg/L	Median mg/L	% of Samples Exceeding "High"	Priority Ranking
Site # 11	0.05	0.04	0	**5**
Site # 12	0.045	0.04	0	**4**

(1 = Lowest Priority and 12 = Greatest Priority)

A comparison of project monitoring results to the values observed in 1996 reveals two sites had monitoring results that exceeded the "high" classification metric for White River tributary streams from the 1996 IDEM study.

A measurement of total phosphorus includes all forms of phosphorus, those that are dissolved in the water and those that are attached to other particles like soil. Phosphorus that is attached to other particles suspended in the water is not soluble and is "particulate" in nature. The primary source of particulate phosphorus is soil loss or erosion from the land. The range for total phosphorus in Indiana waters is quite broad (0.01-0.17 mg/l) with a state average of 0.09 mg/l. 0.03 mg/l is generally thought to indicate eutrophication potential. The Ohio Environmental Protection Agency found that the median total phosphorus in wadeable streams that support modified warm water for fish was 0.28 mg/l.

<u>E. coli Bacteria</u>

E. coli bacteria are associated with the intestinal tract of warm-blooded animals. Although not a pollutant in itself, *E. coli* is widely used as an indicator of the sewage pollution, which may harbor additional waterborne disease causing (pathogenic) bacteria, protozoa, and viruses.

E. coli is an effective indicator because other pathogens are closely associated with its presence and abundance. It is easily measured and is less costly to monitor and detect than the actual pathogenic organisms, such as *Giardia*, *Cryptosporidium*, and *Shigella*, which require special sampling protocols and very sophisticated laboratory techniques. The presence of waterborne disease-causing organisms can cause outbreaks of diseases, such as typhoid fever, dysentery, cholera, and cryptosporidiosis.

Water quality standards (WQS) for *E. coli* have been established in order to ensure safe use of waters for drinking water supplies and recreation. 327 IAC 2-1-6 Section 6(d) states that *E. coli* bacteria, using membrane filter count (MF), shall not exceed 125 per 100 milliliters as a geometric mean based on not less than five samples equally spaced over a 30 day period nor exceed 235 per 100 milliliters in any one sample in a 30 day period.

E. coli bacteria may enter surface waters from non-point source runoff from failing septic systems, straight pipe discharges from septic tanks, livestock, domestic pets, and wildlife. In addition, *E. coli* can also come from improperly treated discharges of domestic wastewater. Common sources of *E. coli* bacteria include leaking or failing septic systems, direct septic discharge, leaking sewer lines or pump station overflows runoff from livestock operations, urban stormwater and wildlife. *E. coli* bacteria in treatment plant effluent are controlled through disinfection methods including chlorination, ozonation, or ultraviolet light radiation.

E. coli monitoring by the IDEM in the Lower White Lick Creek Watershed identified several locations where the WQS for *E. coli* was violated during 2004. Two stream reaches are listed as impaired by E. *coli* on the 2004 Indiana 303(d) list in the Lower White Lick Creek Watershed. These reaches include the main stem and the East Fork of White Lick Creek.

In addition to the IDEM monitoring data, water quality monitoring conducted for this project confirmed the presence of ongoing *E. coli* violations at several locations including Silon Creek, Orchard Creek, Monical Branch, and White Lick Creek.

Monitoring locations were prioritized according to the level of impairment, which was judged by the percentage of times that the *E. coli* water quality standard was exceeded at each site as shown in **Table 2-8**. In most cases, the percentage method of prioritizing sites is appropriate for identifying stream segments with the most need for mitigation; however, this ranking is independent of the results from other parameters. Where sites were tied for the percentage of sample that exceeded the state standard, mean and median rankings were used as tie breakers. The site with the highest average of the two was considered a higher priority in the final ranking.

Table 2-8: Priority Rankings for *E. coli*

Site #	Average CFU	Median CFU	% of Samples Exceeding WQS	Priority Rank
Site # 1	411.08	135	61	**10**
Site # 2	289.94	188	44	**4**
Site # 3	292.27	900	39	**3**
Site # 4	345.5	130	39	**1**
Site # 5	715.35	330	58	**9**
Site # 6	353.88	235	50	**7**
Site # 7	348.11	330	71	**12**
Site # 8	377.35	230	50	**8**
Site # 9	492.44	325	61	**11**
Site # 10	530.65	165	44	**5**
Site # 11	398.38	120	39	**2**
Site # 12	572.47	280	44	**6**

(1 = Lowest Priority and 12 = Greatest Priority)

Monitoring Site 7 (Monical Branch at the Merriman Rd. Bridge west of SR 67) and Site 9 (White Lick Creek at the Centerton Rd. Bridge east of SR 67) are considered the most impaired sites for *E. coli* within the project area. Site 1 (East Fork White Lick Creek at the Bridge on CR 700S in Hendricks Co.), Site 5 (Unnamed tributary to White Lick Creek at the Bridge at SR42 west of Mooresville) and Site 8 (Monical Branch at the bridge at Country Club Rd. north of Brooklyn) also experienced frequent periods of impairment from *E. coli*. In fact, all sites in the watershed exceeded the WQS for *E. coli* at least 39% of the time.

The sources of *E. coli* at Site 7 are not readily apparent; however, given the agricultural nature of the upstream and adjacent land uses, the likely sources of pollution include failing septic systems, livestock operations, or wildlife. Monitoring conducted for this project was not of sufficient detail to distinguish between these potential sources. Site 1 showed significant levels of *E. coli* and indicates that upstream bacteria sources may be contributing significantly to the impairment in the study watershed. However, Sites 2 and 3, several miles downstream from Site 1, show significantly lower levels of bacteria. Therefore, it is not certain how far the influx of bacteria extends into the study watershed and how persistent it is at down stream locations.

Sites 5, 7, and 12 are monitoring locations on tributaries that indicate substantial levels. Considering that these monitoring locations are measuring bacteria that have originated solely from the immediate upstream contributing watershed, then, tit may be inferred that the source of the bacteria must be from the upstream watershed. At other monitoring locations, the source of the bacteria can not be isolated from sources outside of the study watershed, or from sources within the study watershed. Therefore, future management measures should focus on these sub-watersheds where the source of the bacteria has been clearly isolated. In the future, additional monitoring sites can be established to better characterize bacteria contributions from other sub-watersheds throughout the watershed.

Bacteria contamination is common to both rural and urban watersheds in Indiana, and sources contributing to bacteria pollution are very diverse. In recognition of this fact, best management practices implemented to reduce bacterial contamination need to be equally diverse and ought to focus on both urban and rural sources.

Total Organic Carbon

Organic contaminants can enter waterways during periods of stormwater runoff from many sources including insecticides, herbicides, agricultural chemicals, and natural organic substances. Domestic wastewaters from improperly operated wastewater treatment facilities or failing septic systems also contribute organic contaminants in various amounts.

Total Organic Carbon (TOC) measurements are indicative of the number of carbon-containing compounds in a waterbody. The larger the organic carbon content, the more oxygen is consumed. A high organic content means an increase in the growth of microorganisms that contribute to the depletion of oxygen supplies. Elevated concentration of TOC can create unfavorable conditions for aquatic life, such as the depletion of oxygen and the presence of toxic substances.

In the absence of specific surface water quality standards for TOC, monitoring results collected during this monitoring project were also compared to the summary statistics and classification metrics for White River tributary streams from the 1996 IDEM West Fork White River study. An evaluation of the 1996 study's summary statistics indicated that the average concentration of TOC for samples collected in the West Fork White River watershed was 3.78 mg/L, while the median concentration of TOC was 3.8 mg/L. Concentrations of TOC exceeding 4.8 mg/L were considered to be "high".

As illustrated in **Table 2-9**, monitoring locations were prioritized according to the level of TOC impairment, which was judged by the percentage of samples that exceed 4.8 mg/L, or "High" classification metric, as compared to the 1996 IDEM study of the West Fork White River. For sites that do not exceed this high classification, rankings are based on which sites maintained the lowest average TOC results. This ranking is independent of the results from other parameters.

Table 2-9: Priority Rankings for Total Organic Carbon

Site #	Average (mg/L)	Median (mg/L)	% of Samples Exceeding "High"	Priority Ranking
Site # 1	3.04	3	0	**9**
Site # 2	2.9	2.7	0	**8**

Site #	Average (mg/L)	Median (mg/L)	% of Samples Exceeding "High"	Priority Ranking
Site # 3	2.0	2.7	0	**1**
Site # 4	2.83	2.7	0	**7**
Site # 5	2.79	2.3	6	**10**
Site # 6	2.61	2.6	0	**4**
Site # 7	2.19	2.35	0	**3**
Site # 8	2.04	2.1	0	**2**
Site # 9	2.88	2.4	6	**11**
Site # 10	2.82	2.5	0	**6**
Site # 11	2.72	2.6	0	**5**
Site # 12	2.95	2.7	6	**12**

* (1 = Lowest Priority and 12 = Greatest Priority)

A comparison of project monitoring results to the mean and median values observed in 1996 reveals that three stream reaches, Site 5 (Tributary to West fork White Lick Creek at the bridge at SR 42 west of Mooresville), Site 9 (White Lick Creek at Centerton Rd. bridge east of SR 67), Site 11 (Orchard Creek at the bridge at Rooker Rd) and Site 12 (Orchard Creek at the bridge at SR 144 east of Mooresville) had monitoring results that exceeded the "high" classification metric from the 1996 IDEM study. States with a WQS for TOC, have recommended filter strips, riparian buffers, and construction BMPs to minimize TOC contributions in nearby waterways.

Chemical Rankings

A composite ranking of all sites was considered as a method to help prioritize areas within the Lower White Lick Creek Watershed for remedial management action. Physical parameters such as pH, turbidity, total phosphorous, dissolved oxygen, and total organic carbon were separated from *E. coli.* Monitoring results because bacteria concentrations are less of a physical-chemical water quality parameter than it is a contaminant. Furthermore, there is an Indiana State WQS for *E. coli.*, whereas there are no WQS for the other parameters monitored. Additionally, results of the chemical monitoring do not indicate that conditions are poor for the parameters analyzed, except for *E. coli*. Therefore, to rank the monitoring location would not help to identify more impaired areas over others (except in the case of E. coli.) since all parameters generally indicate good conditions throughout the Lower White Lick Creek Watershed. A ranking based on these results would only provide a relative ranking of good conditions and would not effectively identify areas that are in need of more improvement. The ranking table discussed above is provided in Appendix 2.

The exception to the conclusion that a ranking would not be useful is found in the results for *E. coli*. The state WQS for E. coli is 235 CFU/100mL concentration as a one time grab sample and 135 CFU/ 100mL mean concentration over a 30-period of not less than 5 samples during that period. All monitoring locations show average concentrations that exceed the 235 CFU/100mL WQS. The rankings shown in Table 2-8 do effectively demonstrate which sub-watershed areas within the Lower White Lick Creek Watershed are more impaired than others. The rankings presented in Table 2-8 will be used to help identify and prioritize critical areas in the Lower White Lick Creek Watershed for this WMP.

2003 Biological Monitoring

Commonwealth Bio-monitoring, Inc. assessed biotic conditions within the project area at the 12 sampling locations. Results of the macro-invertebrate study showed that the White Lick Creek and the East Fork of White Lick Creek had excellent aquatic habitat. In addition, two tributaries (Monical Branch and Orchard Creek) had relatively good water quality as indicated by macro-invertebrate communities present. However, based on deviations between available habitat and the Index of Biotic Integrity (IBI) scores, results suggest that water quality was degraded at the White Lick Creek and East Fork of White Lick Creek sites. Biological indicators point to the presence of low-level amounts of toxic substances in and excessive nutrient inputs to the White Lick Creek. Additionally, the biological communities showed signs of stress that were indicative of possible excessive sedimentation. The degree of degradation was uniform throughout the study reaches. Sources of observed water quality impairment are likely to originate from upstream and within in the Lower White Lick Creek Watershed.

2.3 BASELINE WATER QUALITY: CONCERNS, CAUSES, AND PROBLEMS

Linking stakeholder concerns with known and discovered water quality issues in the watershed helps to validate initial observations and provides evidence to dismiss others. Thus, a review of past and recent water quality studies can help to guide the planning process toward management actions that are most appropriate and efficient for improving water quality conditions. The following descriptions detail water quality baseline conditions that have been established by prior studies as they relate to stakeholder concerns. These descriptions are organized by listed stakeholder concern, as shown in Section 2.1, and provide the foundation for future watershed management strategy in this WMP.

Agricultural Lands

All studies described above indicate that water quality conditions in the headwater tributaries that are significantly affecting sensitive biotic communities. These biotic communities are on the frontline where water quality degradation is first made evident. Bio-monitoring results show that habitat conditions are fair to good, yet biotic communities are not as robust as they should be given those favorable conditions. The NAQWA results, describe a serious threat from pesticide and herbicide inputs to waterways in the White River Basin. Pesticides and herbicides can adversely impact invertebrate communities in the waterways, and pose unknown human health risk if these contaminants reach private or public drinking wells. Prior studies support the concerns of the Steering Committee regarding nutrient and pesticide runoff impacts to water quality from agricultural sources.

Developments/Developing Lands

New development has the potential to increase runoff volumes and peak discharge flows in a watershed through the creation of impervious surfaces and installation of stormwater collection systems. Additionally, new development can increase the amount of soil that is delivered to a waterway through ground disturbing activities. If new development is not required to install measures that are designed to limit soil erosion and control runoff increases, then conditions in the waterways may deteriorate. Concerns regarding the potential impact of new development on water quality conditions are confirmed by prior study findings that identify stressed aquatic communities due to adverse habitat conditions throughout the watershed. Direct causes of the stressed condition were not specified in any prior study.

Human Waste Disposal

The IDEM study and designation that the White Lick Creek main stem and major tributaries are impaired due to unhealthy levels of *E. coli* bacteria has been confirmed by the chemical monitoring study completed for this WMP. However, sources of the *E. coli* are not specifically located and could be generated from a number of sources. However, suspected sources include failing or illicit septic systems in the Lower White Lick Creek Watershed. The Indiana State Department of Health (ISDH) estimates that approximately 20% – 30% of all septic systems in Indiana are currently failing. Therefore, concerns for the potential contribution of septic systems in the Watershed are reasonable given the levels of *E. coli* reported in waterways from past and recent studies.

Indianapolis International Airport

The 1997 IDEM study concluded that fish communities were not being adversely impacted by the IIA expansion activities. Furthermore, recent chemical and biological monitoring does not suggest that IIA activities are contributing significantly to impaired conditions in the White Lick Creek. Concerns regarding IIA activities impacting water quality in the Lower White Lick Creek Watershed are not supported by prior studies. Thus, this stakeholder concern will not be addressed in subsequent proposed management actions.

Industrial Clean-up: Dumps/Salvage Yards

Fish consumption advisories for the Lower White Lick Creek for PCBs and Mercury suggest that these toxic pollutants persist for long periods of time and may be contributing to contamination through legacy sources such as old dumping grounds in or near floodplain areas. The tire dump in Brooklyn has confirmed PCB contamination in the soils. Some of this contamination may travel to the adjacent White Lick Creek through shallow surface flow over the ground, bank erosion where contaminated soils are directly entering the creek and shallow groundwater flow that drains to the adjacent creek. It is unclear in this study how much contamination to the White Lick Creek is being contributed by this one site, however, the potential is significant. Concerns related to the contribution of solid wastes to water quality are supported by ongoing FCAs in the Lower White Lick Creek Watershed.

Household & Yard Waste

Since impaired conditions and pollutant loading has been detected throughout the watershed, activities in residential areas could be a contributing factor in the level of observed water quality in the water ways. Prior and recent studies were not designed to isolate potential pollutant contributions from urban and rural land uses; however, it is reasonable to assume that because pollutants are present and applied in urban areas, that a portion of those pollutants reach the Lower White Lick Creek Watershed waterways. Concerns about urban activities contributing to water quality impairment are supported by common knowledge of urban activities and existing poor water quality conditions in the Watershed.

Commercial/Industrial Properties

Golf courses have the potential to be a significant source of fertilizer and pesticides loading to waterways as these products are used to establish and maintain vegetation that has been specifically design for golf course functions. Since prior studies have found excessive levels of pesticides and nutrients in the Lower White Lick Creek Watershed waterways, then golf course would have to be considered a potential contributor to the existing problem. The shale mining operation in the Monical branch watershed is a land disturbing commercial activity with the potential to contribute fine sediments to the Monical Branch of the White Lick Creek. Concerns for commercial activities are generally supported by prior study findings related to habitat stresses and nutrient and pesticide prevalence; however, there is little specific evidence presented in the past, or recently, that would indicate that these potential pollutant sources should be targeted for future management action.

3.0 IDENTIFYING POLLUTANT SOURCES

A number of substances including oxygen demanding wastes, nutrients, bacteria, metals, and toxic substances, cause water pollution. Sources of these pollutants are divided into two broad categories: point sources and non-point sources. Prior sections of the WMP have identified stakeholder concerns, presented past and recent evidence of impairment, and discussed whether that evidence supports or negates those stakeholder concerns. This section attempts to present, in detail, possible sources of pollution to the waterways that have been identified as issues or concerns. Where possible, the magnitude and extent of pollutant sources are supported by pollutant loading estimates.

3.1 POINT SOURCE POLLUTION

Point source pollution refers to discharges that enter surface waters through a pipe, ditch, or other well-defined point of discharge. The term applies to wastewater and stormwater discharges from a variety of sources. Wastewater point source discharges include municipal (city and county), industrial wastewater treatment plants, and small domestic wastewater treatment systems that may serve schools, commercial offices, residential subdivisions, and individual homes. Stormwater point source discharges include stormwater discharges associated with industrial activities and stormwater discharges from municipal separate storm sewer systems (MS4s) for municipalities that meet the requirements of 327 IAC 15-13.

The primary pollutants associated with point source discharges are oxygen demanding wastes, nutrients, sediment, toxic substances, ammonia, and metals. Point source dischargers in Indiana must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state. Discharge permits are issued under the NPDES program, which is delegated to Indiana by the US Environmental Protection Agency (EPA). Point discharges may also originate from underground storage facilities or registered industrial waste sites. Environmental hazard sites are identified in **Exhibit 9**.

As of November 2004, there were 8 active NPDES permitted facilities directly within the Lower White Lick Creek Watershed and there are no known Combined Sewer Overflow (CSO) locations. A CSO is the discharge from a combined sewer system at a point prior to the wastewater treatment plant. CSOs are point sources of bacteria and viral pollution subject to NPDES permit requirements that include both technology and water quality based requirements of the Clean Water Act. NPDES facilities in the Lower White Lick Creek Watershed and Morgan County are listed in **Table 3-1** and illustrated in **Exhibit 10.** These NPDES permitted facilities are listed here as potential sources of pollution, and not confirmed sources of existing impairments in the study watershed.

Table 3-1: NPDES Permit Holders in the Lower White Lick Creek Watershed

Permit #	Name	Owner Type	Design Flow (gal./day)	Permit Type	Receiving Water
IN0023825	Mooresville Municipal STP	Public	1,500,000	Standard	White Lick Creek
IN0030023	Ashbury Ridge	Public/Private	37,900	Standard	Un-named Tributary,

Permit #	Name	Owner Type	Design Flow (gal./day)	Permit Type	Receiving Water
	Mobile Home Court				White Lick Creek
IN0039772	Brooklyn Municipal STP	Public	239,990	Standard	White Lick Creek
IN0058645	Thiesing Veneer Co.	Private	35,990	Standard	East Fork White Lick Creek
IN0059072	Country View Estates	Public/Private	29,990	Standard	Unnamed Tributary, White Lick Creek
IN0060551	John M. Wooley Lumber Co.	Private	82,000	Standard	White Lick Creek
ING080109	Marathon Service Station #3079	Private	50,000	General	City Storm Sewer to White Lick Creek
INP000158	Linel Signature	Private	3,000	Pre-treater	Mooresville STP

(IDEM, 2005)

There are 2 publicly owned, 2 permitted semi-public, and 4 privately owned wastewater treatment facilities within the Lower White Lick Creek Watershed. A Publicly Owned Treatment Works (POTW) includes moderate to large capacity municipal wastewater treatment plants that typically serve large populations on a sewer network. Semi-public wastewater treatment plants or “package plants” are typically much smaller versions of a POTW that are used to treat sewage for subdivisions, schools, or mobile home parks that are located too far away from a POTW to be cost effectively connected to a larger centralized wastewater treatment facility. Private dischargers are usually industry related with small daily discharges, though some may be significant contributors of pollution to nearby waterways. Although much smaller in size and discharge volume than POTWs, semi-public wastewater treatment facilities are common sources of water quality impairments for oxygen consuming wastes, nutrients, and *E. coli* bacteria.

Stormwater from urban areas and from certain industrial and construction sites is considered a point source since NPDES permits are required for discharges of stormwater from these areas. The State of Indiana has adopted regulations implementing Section 402 of the Clean Water Act through Phase II of the Federal Stormwater NPDES program. The Storm Water Phase II program will require municipal entities with populations greater than 10,000 to develop stormwater management programs. Morgan County, the City of Mooresville, Town of Brooklyn, and the Tri-county Conservancy District are Storm Water Phase II entities within the Lower White Lick Creek Watershed as shown in **Exhibit 11**.

There have been several recorded occasions of NPDES violations by permit holders in the Lower White Lick Creek Watershed. These violations do not necessarily indicate a chronic problem from these dischargers and the NPDES program provides a process for recognizing and addressing excess pollutant discharge to the Lower White Lick Creek Watershed waterways. These violations do suggest that, from time to time, these dischargers contribute pollutants to the system. Closer examination of these dischargers may be warranted if future NPS pollution control measures do not appear to have an effect on water quality in the watershed.

3.2 NON-POINT SOURCE POLLUTION

Non-point source (NPS) pollution refers to runoff that enters surface waters by stormwater runoff, contaminated ground water, snowmelt, or atmospheric deposition. There are many types of land use activities that can serve as sources of non-point source pollution due to the presence of impervious surfaces, including land development, construction, mining operations, crop production, animal feeding lots, agricultural drainage tiles, timber harvesting, failing septic systems, landfills, roads and paved areas, and wildlife. These sources may contribute a single pollutant or a combination of pollutants such as, *E. coli* bacteria, heavy metals, pesticides, oil and grease, and any other substance that may be washed off the ground or removed from the atmosphere and carried into surface waters.

3.2.1 NON-POINT SOURCES IN RURAL AREAS

The National Water Quality Inventory (NWQI), sponsored by the EPA, reports that agricultural NPS pollution is the leading source of water quality impacts to surveyed rivers and lakes, the third largest source of impairments to surveyed estuaries, and a major contributor to ground water contamination and wetlands degradation.

Non-point source pollutants that result from agricultural activities include nutrients, pesticides, sediment, and bacteria as shown in **Table 3-2**. Nutrients, pesticides, and sediment can migrate from agricultural lands to surface and ground waters through processes such as surface runoff, erosion, and infiltration. It is important to note that these pollutants are not exclusively a product of agricultural production and can originate from residential and/or urban areas as well.

Table 3-2: Non-point Source (NPS) Pollution and Agriculture

Pollutants	Agriculture Sources
Nutrients	Commercial Fertilizers and Manure
Toxic Chemicals	Herbicides, Insecticides, Fungicides
Sediment	Tillage, sheet, rill, gully and streambank erosion
Livestock Waste	Manure runoff from fields, pastures, and feedlots

(EPA, 2002)

Activities associated with agriculture can serve as potential sources of water pollution:

1. Land clearing and tilling make soils susceptible to erosion, which can then cause stream sedimentation,
2. Pesticides and fertilizers (including synthetic fertilizers and animal wastes) can be washed from fields or improperly designed storage or disposal sites,
3. Construction of drainage ditches on poorly drained soils enhances the movement of oxygen consuming wastes, sediment and soluble nutrients into groundwater and surface waters.

According to 2000 USGS land use data, there were approximately 10,840 acres of row crop and 9,867 acres of pasture in the watershed, which accounted for approximately 74% of the watershed area. Since 2000, there has been residential and commercial development that has removed land that had previously been devoted to agricultural production. Unfortunately, more recent land use data was not available at the time that this WMP was developed. Nonetheless, it is very likely that the dominance of agriculture in this Lower White Lick Creek Watershed has diminished since 2000 and will continue to diminish as additional development converts agricultural land to low-density residential, commercial, and industrial uses. Thus, pollutants from agricultural production activities may decrease, while pollutants associated with residential and commercial development will likely increase.

Crop Production

Corn, wheat, forage (hay), and soybeans dominate the crops grown in Morgan County. The 2002 corn and soybean statistics for Morgan County are detailed in **Table 3-3**.

Table 3-3: Morgan County Farm & Crop Statistics

Farm Statistic	Count	Acres
Farms	690	111,609
Land in farms - Average size of farm	162	-
Land in farms - Median size of farm	55	-
Total cropland	562	88,996
Cattle and calves inventory	5,821	-
Cattle and calves inventory - Beef cows	2,643	-
Cattle and calves inventory - Milk cows	260	-
Hogs and pigs inventory	6,264	-
Sheep and lambs inventory	698	-
Layers 20 weeks old and older inventory	363	-
Corn for grain	-	36,447
Corn for silage or greenchop	-	254
Wheat for grain, all	-	1,036
Wheat for grain, all - Winter wheat for grain	-	1,036
Soybeans for beans	-	37,113
Forage - land used for all hay and all haylage, grass silage, and greenchop	-	6,090
Vegetables harvested for sale	-	173
Land in orchards	-	328

(NASS, 2005)

<u>Nutrients</u>

Nutrients such as phosphorus (P) and nitrogen (N) in the form of commercial fertilizers, manure, sludge, legumes, and crop residues are applied to enhance crop production. In small amounts, N and P are beneficial to aquatic life, however, in over abundance; they can stimulate the occurrence of algal blooms and excessive plant growth.

Algal blooms and excessive plant growth often reduce the dissolved oxygen content of surface waters through plant respiration and decomposition of dead algae and other plants. This situation can be accelerated in hot weather and low flow conditions because of the reduced capacity of the water to retain dissolved oxygen.

Fish and aquatic insects use oxygen that is dissolved in water. When there is an algal bloom, nutrients for rapid growth are quickly used up and the algae population crashes. Following the crash, the decomposition of the dead algae uses dissolved oxygen, thereby depleting the waterbody of dissolved oxygen. The result is massive and fish kills and dead zones where little biological activity can be found, these areas are called hypoxia zones.

The Office of the Indiana State Chemist annually publishes the total tonnages of commercial fertilizers sold in each Indiana County. The 2002 figures for Hendricks, Marion, and Morgan Counties were used below to calculate the estimated pounds of nitrogen and phosphorus applied on agricultural lands in Lower White Lick Creek Watershed as shown in
Table 3-4.

Table 3-4: Estimate of Nutrients Applied in Lower White Lick Creek Watershed

County	% of County in Watershed	x	Total Nutrients (tons)		X 2,000 lbs/ton	Nutrients in Watershed (lbs)	
			N	Phosphate		N	Phosphate
Morgan	8.6	x	2,872	1,333	X 2,000	493,984	229,276
Hendricks	1.4	x	5,383	2,785	X 2,000	150,724	77,980
Marion	0.9	x	3131	754	X 2,000	56,358	13,572
Total						**701,066**	**320,828**

(Indiana State Chemist, 2002)

The table shown above describes an estimate of the amount of fertilizer applied in the Lower White Lick Creek Watershed and is not an estimate of loading to waterways. It is expected that only a portion of the applied fertilizer nutrients would be mobilized to the waterways. For example, nitrogen-nitrate is very water soluble. That fraction of nitrogen-nitrate not used by crop vegetation could infiltrate to groundwater or travel with surface runoff to the watershed aquifers and waterways. An estimate of that fraction is too difficult given the wide range of factors that could influence how nitrogen-nitrate is transported through the watershed. Excess phosphorous typically binds to small clay particles or organic material and is transported by surface runoff and erosion processes. Again, an estimate on the fraction of applied phosphate that enters the waterways of the Lower White Lick Creek Watershed is too difficult given the complex processes involved in phosphate transport in runoff processes. Nonetheless, efforts can be undertaken to reduce the possibility that excess nutrients through BMPs and other conservation measures.

<u>Pesticides</u>

Pesticides include a broad array of chemicals used to control plant growth (herbicides), insects (insecticides), and fungi (fungicides). These chemicals have the potential to enter and contaminate water through direct application, runoff, wind transport, and atmospheric deposition.

They can kill fish and wildlife, contaminate food and drinking water sources, and destroy the habitat that animals use for protective cover. Prior studies have shown that pesticides are present at elevated levels in waterways throughout the study watershed.

While some pesticides undergo biological degradation by soil and water bacteria, others are very resistant to degradation. Such non-biodegradable compounds may become "fixed" or bound to clay particles and organic matter in the soil, making them less available. However, many pesticides are not permanently fixed by the soil. Instead, they collect on plant surfaces and enter the food chain, eventually accumulating in wildlife such as fish and birds. Many animals and humans are known to have adverse reactions to pesticides that directly affect or accumulate to dangerous levels of concentration in the body, thereby damaging the nervous, endocrine, and reproductive systems, cause cancer, or outright kill.

The Office of Indiana State Chemist does not track pesticide sales within Indiana counties. A rough estimate of pesticide application for the Lower White Lick Creek Watershed was calculated using information from the USDA Agricultural Statistics Board and is presented in **Table 3-5**.

Table 3-5: Estimate of Pesticide Application in Lower White Lick Creek Watershed

Crop	Crop Acres	X	Pesticide	2003 Fraction of Acres Treated in Indiana	X	2003 Average Rate of Application	=	Estimated Pounds of Pesticides Applied
Corn	36,447	X	Atrazine	.68	X	1.04	=	25,775
			Metolachlor*	.52		1.83		34,683
			Acetochlor	.26		1.88		17,815
			Primisulfuron	.14		0.03		153
			Cyanazine	.05		.098		179
Soy-bean	37,113		Glyphosate*	.49		.87		15,821
			Chlorimuronethyl*	.14		0.02		104
			2,4-D*	.30		0.42		4,676
			Imazethapyr*	.33		0.06		735

(NASS, 2004) *Data from National Center for Food & Agriculture Policy, 1997.

Sources of pesticides to waterways in the Lower White Lick Creek Watershed in rural areas are agricultural fields and golf courses. All farm fields identified on the land use map are potential sources of pesticides. Additionally, there are two golf courses in the Lower White Lick Creek Watershed that may apply pesticides regularly as part of course vegetation and pest management.

<u>Erosion and Sedimentation</u>

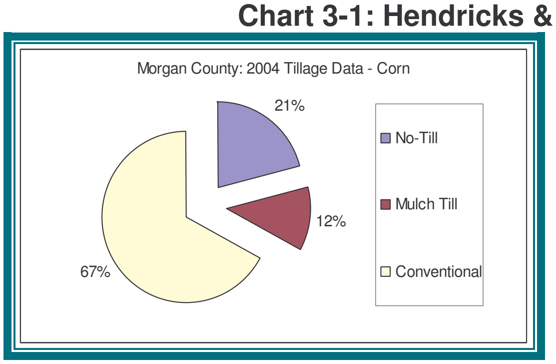
Erosion and sedimentation occur when wind or water runoff carries soil particles from an area, such as a farm field or stream bank, and transports them to a water body, such as a stream or lake. Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic plants; covers fish spawning areas and food supplies; and clogs the gills of fish. Furthermore, pollutants such as phosphorus, bacteriological and viral pathogens, and heavy metals move through the landscape attached to microscopic soil and organic particles; these same microscopic particles are easily transported in overland flow and are stored in and carried by streams throughout the watershed.

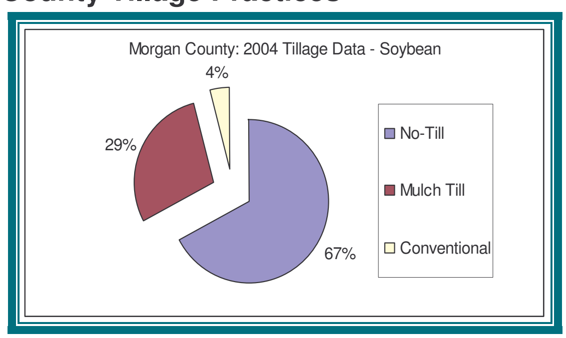
Areas with highly erodible soils, if not managed properly, can erode at an accelerated rate and may lead to excessive soil deposition in waterways. Erosion rates and extent of channel degradation and aggradation in the channel system of the Lower White Lick Creek Watershed is not in the scope of this WMP. Highly Erodible Land (HEL) in the Lower White Lick Creek Watershed was not identified, though they likely exist in the watershed. Future iterations of this WMP could look into the extent of these HEL areas for further study and possible management action.

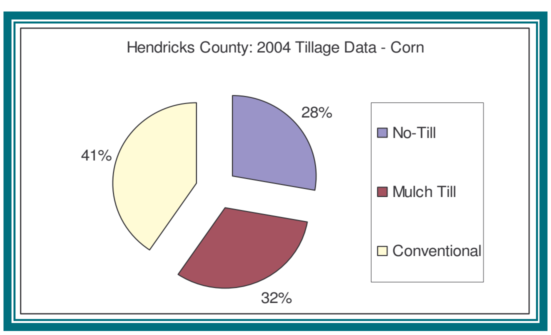
Tillage Practices

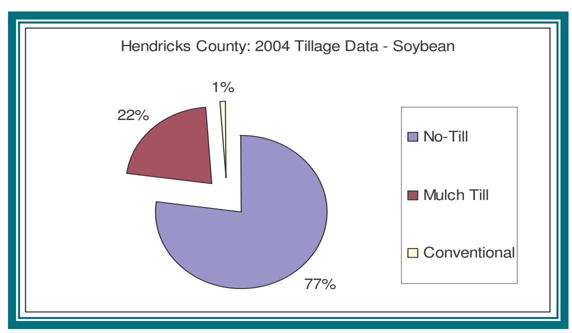
The Indiana 2004 Tillage Statistics for Hendricks and Morgan Counties are detailed below in **Chart 3-1**. Tillage practices differ slightly between both counties and crop type. Farmers in Hendricks County appear to apply no-till, or mulch-till practices more than farmers in Morgan County. The difference in application of these tillage practices may be explained by the soil types encountered in the two counties, or it may be a matter of farming custom and practice. In either case, current application of tillage practices should be considered when formulating potential activities in the WMP. If no-till practices could be increased for corn production in the Lower White Lick Creek Watershed, this may help to reduce the loading of fine clay particulates and surface erosion materials that are delivered to waterways.

Chart 3-1: Hendricks & Morgan County Tillage Practices









(NRCS, 2005)

Assuming that the Morgan County conventional tillage rates for corn and soybeans are applicable to agricultural practices within the Lower White Lick Creek Watershed, and there are equal proportions of corn and soybeans in row crop land use; then, approximately 3848 acres of additional cropland could be targeted for no-till practices in the future. Conventional tillage farm fields are potential sources of sediment and associated pollution. Conventional tillage farm locations are not specified in this plan, though a rough estimate of the magnitude of conventional tillage is provided.

Bacteria and Pathogens

Manure, whether applied for crop nutrition or simply the by-product of grazing is a water quality concern in the Lower White Lick Creek Watershed. The nitrogen and phosphorus that make manure so productive on farm fields and pastureland can create an over-fertilized "soup" when they run off into the water, leading to undesirable algae blooms. These effects are unpleasant for recreation and aesthetics, and deteriorate the underwater habitat necessary for fish and other aquatic organisms to live.

Morgan County reported 6,264 head of hogs in 2002. Hog operations in excess of 600 hogs are required, by IAC 16-2-5, to obtain a permit from the Office of Land Quality at the IDEM. In 2002, Morgan County reported 5,821 head of cattle and calves as shown in **Table 3-6**. Cattle production in Morgan County includes both beef and dairy cattle. Cattle operations in excess of 300 head are required by IAC 16-2-5, to obtain a permit from the IDEM. Morgan County reported 698 head of sheep in 2002, as shown in Table 3-6. Sheep operations in excess of 600 head are required by IAC 16-2-5, to obtain a permit from the IDEM. A review of the IDEM CAFO records does not indicate there are any regulated hog, cattle, or sheep facilities within the Lower White Lick Creek Watershed.

Table 3-6: 2002 Agricultural Census Data - Livestock

County	Hogs	Cattle	Sheep
Morgan	6,264	5821	698
Hendricks	19,212	5698	797
Marion	N/A	759	252

N/A = data not available
(NASS, 2004)

The information on livestock numbers is for all of Morgan County. Information on specific numbers of hog, cattle, and sheep farms in the Lower White Lick Creek Watershed were not readily available. It is important to note, however, that there are no registered CAFO facilities and information on manure application in the Lower White Lick Creek Watershed is also not readily available. Thus, contribution of bacteria from livestock or livestock manure in the Lower White Lick Creek Watershed may contribute to bacteria loading, though it is difficult to reasonably assess the magnitude of the contribution at this time for this WMP.

3.2.2 NON-POINT SOURCES IN URBAN AREAS

A change in land use, especially from field or forest to urban development, has a significant impact on water quality. Not only is the permeability of the soil affected by construction compaction and impervious coverage such as rooftops, driveways, and parking areas but there is an increase of biological and chemical waste from human use. The sources of water quality pollution from urban area are grouped into three categories: human, wildlife, and pet waste, household and yard waste, and development practices and encroachment.

Human Waste Disposal

Bacteria and Pathogens

Urban sources of *E. coli* bacteria are most commonly associated with point source discharges from municipal wastewater treatment plants and regulated stormwater programs; however, failing septic systems and waste from wildlife and pets are additional contributors of NPS pollution to the Lower White Lick Creek Watershed.

Septic systems can be a safe and effective method for treating wastewater if they are sized, sited, and maintained properly. However, if the tank or absorption field malfunctions or if they are improperly sited, constructed, or maintained, nearby wells and surface waters may become contaminated. Some of the potential problems from malfunctioning septic systems include polluted groundwater, bacteria, nutrients, toxic substances, and oxygen consuming wastes that can contaminate nearby wells.

Pollutants associated with onsite wastewater disposal may also be discharged directly to surface waters through direct pipe connections between the septic system and surface waters (straight pipe discharge). Although, 327 IAC 5-1-1.5 specifically states that "point source discharge of sewage treated or untreated, from a dwelling or its associated residential sewage disposal system, to the waters of the state is prohibited," many cities, towns, and county health departments are overwhelmed by the magnitude of the failing septic system problem.

During the planning process for the Lower White Lick Creek WMP, stakeholders discussed suspected instances of failing septic systems or straight pipe discharges. Staff of the Morgan County Health Department confirmed that failing septic systems were considered a significant problem in the County. The City of Mooresville and the Town of Brooklyn serve those residents within their respective municipal bounds with sewer service. Outside of these municipalities, septic systems provide the primary mechanism for wastewater treatment for most parts of the study watershed.

Data from the IDEM and project monitoring identified *E. coli* concentrations in White Lick Creek to be of concern during both dry and wet weather conditions. Concentrations of *E. coli* at all sites were frequently at levels in excess of the Indiana standard. Monitoring locations that are most notable for elevated levels of bacteria are Sites 1, 5, 7, and 12.

According to 2000 U.S. Census records and information available from the Indiana Department of Health, the occurrence of septic systems in central Indiana is roughly 1 for every 30 acres. There are 28,144 acres in the Lower White Lick Creek Watershed, that yields and estimate of 9,381 septic systems. State estimates for the failure rate of septic systems in Indiana range between 20% - 30%, and depend on age, ongoing maintenance, and soil conditions where they are installed. Assuming a 25% failure rate in the Lower White Lick Creek Watershed, the number of potential failing septic systems is 1,876.

Daily loading of *E. coli* bacteria can be estimated from Morgan County census information. Assuming the concentration of typical septic effluent is 1.07×10^{6} CFU/100 mL, 1,876 failing septic systems, with 2.5 persons per system, releasing 75 gallons per person per day; daily loading is estimated to be 1.4×10^{13} CFU/day distributed evenly throughout the Lower White Lick Creek Watershed. This is an estimate of total daily loading and is difficult to compare to the Indiana Water Quality Standard (WQS) of 235 CFU/100 mL concentrations in a waterway. Therefore, load reduction estimates for this WMP will specify an estimated reduction of the total daily contribution to the Lower White Lick Creek Watershed, and will be monitored using the Indiana WQS for *E. coli*. A TMDL study may, in the future, help to more definitively identify bacteria sources and ascribe proper load allocations for these point and non-point sources.

Wildlife and pet wastes also contribute significantly to the amount of bacteria and organic nutrients in stormwater runoff. Ducks and geese frequently nest in colonies located in trees and bushes near rivers, streams, and lakes. The presence of waterfowl has been associated with elevated levels of ammonia, organic nitrogen, and *E. coli* bacteria. In addition, waterfowl activity can increase sediment loadings by pulling up grasses and sprouts and trampling emergent vegetation along streambanks and shorelines, significantly affecting rates of erosion and sediment transport to water bodies. The magnitude of bacteria contributions from wildlife is unknown and beyond the scope of this WMP; though, future studies, such as a TMDL, should provide an estimate for this contribution as part of the bacteria load allocation analysis.

Household and Yard Waste

Every home, regardless of size or age, has potential pollution sources that can affect ground and surface water quality. These may include the use, storage, and disposal of pesticides, solvents, and petroleum products. Proper use, storage, and disposal of household waste such as used motor oil, paints, furniture stains, and mercury thermostats for example are important to prevent contamination of ground and surface water. Additionally, yard waste such as grass clippings, leaves, and dead plants are high in organic matter. Yard waste that is piled or dumped on nearby streambank may result in lowered dissolved oxygen in waterways that can impair aquatic communities.

The Steering Committee has identified illegal dumping in the study watershed as a serious problem that needs to be addressed. Many toxic and other wastes are routinely dumped at river or stream crossings, either into the waterway or in the adjoining floodplain. This is a common conduit for toxic and other household wastes to enter the waterways of the study watershed. Therefore, all isolated major stream crossings in the Lower White Lick Creek Watershed are potential sources of pollutants that could contribute toxic substances to waterways.

Development/Developing Properties

Nationwide, more than 1.5 million acres of land is developed each year. Development pressure is growing in the Lower White Lick Creek Watershed and the threat of encroachment on riparian corridors and detrimental impacts from new developments are greater than at any previous time in the County. To ensure that water quality improves, effective planning, adoption, and enforcement of watershed protective development ordinances are necessary measures to control not only where development occurs but also how it occurs.

Increased development pressure has made preserving open space and agricultural land more difficult in Morgan County. Open fields, river corridors, wetlands, and wooded areas have become targets for residential development. Increased development and depletion of natural drainage and filtration systems will have an adverse effect on water quality. Soil erosion from construction activities can contribute to filling of nearby waterways affecting water quality, aquatic habitats, and recreational opportunities. There are a number of BMPs, including silt fencing, straw bales, and turf seeding, that when installed and maintained properly, can successfully limit sediment from leaving the site.

MS4 Erosion Control measures as stipulated by Rule 5 and Rule 13 for municipalities have been implemented recently in Morgan County. MS4 communities are shown in Exhibit 11. These communities are required to adopt and enforce stormwater management, soil, and erosion control measures for existing and future development in those communities. Additionally, the Morgan County surveyor and the Morgan County SWCD must review development plans for soil and erosion control status prior to a permit being granted for the development. Efforts are currently underway to educate and inform developers in the study watershed about the new MS4 regulatory requirements and associated permitting process.

All new development areas in the Lower White Lick Creek Watershed are potential sources of sediment to waterways. However, much of the Lower White Lick Creek Watershed is covered by MS4 regulations that address the issue of stormwater and sedimentation from municipal areas.

Channel erosion that is induced by new development stormwater increases may also contribute a significant amount of sediment during storm events. Streambank erosion is a natural process. However, in developing areas, the process is accelerated by alterations to the streams natural hydrology such as more frequent and larger stormwater flows. Sedimentation from streambank erosion is compounded by increased imperviousness, loss of floodplain, and loss of riparian corridor. Riparian corridors are an integral part of the stream ecosystem. These areas consist of large trees with wide canopies, smaller woody shrubs, and herbaceous groundcover. Riparian corridors naturally function to filter and trap sediments and pollutants; anchor the streambank to prevent erosion; and shade the creek making it more habitable for aquatic species.

The USDA suggests that riparian corridors measure at least 95 feet in width on both sides of the stream. The corridor is divided into three distinct zones. Zone 1 is 15' minimum in width and composed of undisturbed forest; Zone 2 is 60' minimum in width and contains a managed forest; and Zone 3 is 20' minimum in width and serves to control the velocity and volume of stormwater runoff.

In the Lower White Lick Creek Watershed, approximately 72%, or 52 out of 72 miles, of streams in the study watershed are bordered by a sufficiently wide riparian corridor according to the above USDA recommendations. A sufficiently wide riparian corridor helps to ensure proper filtration and buffering capacity of soil and nutrient movement from the landscape to the waterway. Riparian buffers provide a valuable filter for fine particulates and excessive nutrients between upland areas and the stream channel. Additionally, deep rooted systems of forested riparian areas help to retard bank erosion processes. These areas should be protected from encroachment and corridors lacking sufficient vegetative cover should be reforested.

Approximately 20 miles of un-buffered reaches may be a source of excess sediment in the Lower White Lick Creek Watershed. Estimation of the potential contribution of sediment from the un-buffered stream reaches is complicated by the complex processes and conditions that define rates of bank erosion. Nonetheless, a gross assumption can be made that these reaches are losing about 0.2-foot laterally on each bank per year. Given that erosion rate assumption, these un-buffered reaches may contribute approximately 61 tons of sediment per year to waterway s in the Lower White Lick Creek Watershed. Un-buffered reaches are identified in **Exhibit 12**.

4.0 IDENTIFYING CRITICAL AREAS

Preliminary steps in formulating watershed management options involved identifying and characterizing sources within the watershed that contribute to the water quality impairments. The investigation of these processes and pollutant sources helped to build an understanding of water quality impairments in the context of how stakeholders use and influence water throughout the watershed. The Steering Committee examined, discussed, and weighed the costs and benefits of various NPS pollutant sources, potential controls, and water quality targets. Watershed issues were categorized by rural and urban pollutant sources associated and ranked by importance to the community. The Committee was sensitive to divisiveness between agricultural and urban community stakeholders regarding water management, and attempted to treat these land use activities equally in the rankings to avoid the appearance of blame for poor water quality on one group or the other.

4.1 PRIORITIZATION OF WATER QUALITY ISSUES

The water quality issues presented in this section are a combination of community values and scientific discovery in the Lower White Lick Creek Watershed. Thus, the prioritization of water quality concerns is not solely based on the results of the chemical monitoring study. While a prioritization of locations by science alone would be beneficial; including community values and perception of water quality as part of the ranking process helps to better address public concerns and link public motivation to specific water quality action areas. Thus, this prioritization is a hybrid ranking of water quality issues and has special significance for keeping the watershed management plan grounded to the community.

Urban Issues

1. Industrial Clean-up
   Toxic chemicals may be leaching into the White Lick Creek and groundwater that could threaten existing or future drinking water supply. The White Lick Creek flows adjacent to an old dumping area in Brooklyn. The dump covers approximately 5 acres, and prior soil tests conducted by the IDEM show high levels of PCB, heavy metals, and other toxic contaminants.

2. Development (MS4)
   Future development has the potential to significantly alter the hydrologic regime and erosion conditions in the study watershed. Existing planning and zoning ordinances do not specifically address water quantity and quality issues associated with landscape alteration by new development. Water quality may be degraded if soil erosion control measures are not enforced, and runoff quantity may increase if detention requirements are not stipulated for new development. New development is occurring throughout Morgan County; however, the northern portion, near the Heartland Crossing development, of the Lower White Lick Creek Watershed is experiencing the greatest development pressure at this time.

3. Human Waste Disposal
   The main stem and major tributaries of the White Lick Creek have been designated as impaired by *E. coli* bacteria by the IDEM. A likely source of the bacteria is illicit and/or failing septic systems. Septic systems are scattered throughout the watershed; however, only those within a short distance to a waterway are likely to contribute bacteria to the waterway. Those homes that use a septic system and are within 500 yards of a waterway are potential

contributors of bacteria. Additionally, many septic fail due to poor soil conditions. Thus, those homes that have septic systems installed in unsuitable soil conditions are more likely to have a failing septic system. As was discussed as part of the watershed discussion, nearly 62% of all Morgan County soils are not suitable for residential development. Additionally, most residences in Mooresville and Brooklyn are serviced by a waste water treatment plant. However, there may still be pockets where the sewer infrastructure in the municipal boundary has not yet reached and where septic systems are still in use.

4. Household and Yard Waste
   Illegal trash dumping is prevalent throughout the study watershed and may contribute significantly to solid and toxic waste pollution in the Lower White Lick Creek Watershed. A common practice is to dump trash at secluded river or stream crossings, or in floodplain areas. These areas should receive priority as they are easily accessible by the general public and are frequently used.

Rural Issues

1. Crop Production
   Both nutrient and pesticide contamination in the study watershed are a concern. Agricultural crop production is the source of fine sediments, nitrates, and phosphorous that contributes to observed low levels of oxygen and poor habitat quality for flora and fauna in all waterways in the study watershed. Pesticide and herbicide use also contribute to surface water and groundwater contamination, though previously recorded levels do not indicate a significant health hazard to humans at this time. However, the prevalence of active herbicides and pesticides in the waterway may have an impact on non-target invertebrate communities and plant communities, and may have unknown human health impacts.

2. Illicit Trash Dumping
   Illegal trash dumping is prevalent throughout the study watershed and may contribute significantly to solid and toxic waste pollution in the Lower White Lick Creek Watershed. A common practice is to dump trash at secluded river or stream crossings, or in floodplain areas. These areas should receive priority as they are easily accessible by the general public and are frequently used. All floodplain areas are designated as critical areas that not only require preservation, but also enhancement. Generally, these areas are already protected by the Clean Water Act and the 404 and 401 Water Quality Permitting programs. Thus, they are mentioned here, but are not specifically mapped.

3. Human Waste Disposal
   Most waterways in the study watershed appear to be impaired by high levels of *E. coli* bacteria. Though the specific source of the high levels is not identified in this study, likely sources are failing septic systems. Since many residents of the City of Mooresville and the Town of Brooklyn are served by waste water treatment plants, those residents outside of these municipalities are most likely using a septic system to service their bio-wastes. Failing septic systems that are contributing bacteria to the waterways are most likely to be found in those areas where soil conditions are not conducive to infiltration, are within 500 yards of a waterway, and were installed more than 20 years ago.

4. Livestock Production
   Elevated levels of *E. coli* bacteria are found in isolated rural sub-watersheds. A potential source of the bacteria is livestock production. Cattle, sheep, pig, and horses may have access to or waste may drain to a nearby waterway, thereby the bacteria are directly added

to the waterway. Livestock production is not as prevalent in Morgan County, or in this study watershed, as it is in other parts of Indiana. However, a pasture where livestock have access to the waterway may be a local source of bacteria. Since there are no known, or registered, CAFOs in the Lower White Lick Creek Watershed and no further information on livestock pasture locations that affect any waterway in the Lower White Lick Creek Watershed, no critical area locations are specified at this time for this issue. However, future studies, such as a TMDL, may identify specific locations where livestock operations are contributing bacteria to the waterways.

4.2 CRITICAL AREAS

Critical areas in the watershed are defined as areas where water quality is very good and should be preserved, and also areas where management measures, when applied, are thought to have the greatest potential benefit for improving water quality. Keeping in mind the prioritized water quality issues, the Steering Committee identified the following areas as needing special attention based on public visibility, greatest water quality benefit, and economic feasibility. Both beneficial and pollutant source critical areas are illustrated in **Exhibit 13**.

Beneficial Critical Areas

Open Space/Greenways Areas

The Indianapolis International Airport (IIA) has purchased and created many acres of mitigation wetland and natural areas in the northern portion of the Lower White Lick Creek Watershed, in Hendricks County. Stream corridors, floodplains, and upland areas that are adjacent to existing IIA mitigation property should be given special status for future mitigation holdings. The objective would be to increase the amount of contiguous land that has been set aside as natural habitat or wetland mitigation. Large contiguous natural areas are more likely to provide a recreational and educational resource to the community than if there were many scattered and diffuse mitigation areas. Additionally, there are benefits for wildlife and natural plants communities within larger, contiguous land areas. If a large area can be consolidated as a natural protection area, then the community can benefit in additional ways beyond simply improved water quality. Thus, large park would serve as a destination place, water quality preservation area, and a quality of life asset to the community.

Other open space, or special status areas, to consider are areas within the floodplain and immediately adjacent to the White Lick Creek. Many floodplain areas are currently farmed. However, removing farmland from the floodplain of the White Lick Creek, even creating wetland depressions in the floodplain, will help to keep flooding potential down, will help to filter flood waters, provide habitat, and upland filtration as well. These floodplain areas should be acquired and retired to permanent natural areas.

Buffered Streams

Conservation buffers are vegetated corridors along natural waterways and drainage ditches and are an integral part of the function of a healthy waterway system. Conservation buffers along natural streams consist of a natural and dense network of grasses, shrubs, and trees. Whereas buffers along drainage ditches are swaths of mowed cool season grasses, regularly maintained to prevent the development of woody plants. Although the appearance of conservation buffers differs between natural streams and drainage ditches, the functions remain the same – to improve water quality by filtering and trapping sediments and pollutants, storing excess stormwater, and creating aquatic and terrestrial habitats.

CBBEL conducted a windshield survey of the waterways and carefully reviewed recent aerial photography of buffered and un-buffered waterways in the Lower White Lick Creek Watershed. Of the 72 miles of waterways in the Watershed, approximately 20 miles (28%) of the streams lacked sufficient conservation buffers as shown in Exhibit 12. While there are approximately 20 miles of un-buffered reaches along the White Lick Creek and its tributaries, there are some areas that provide a riparian buffer between adjacent land uses and the creek. These areas are important for maintaining water quality temperature, and habitat. Therefore, these areas should be preserved.

Forested Areas

The Lower White Lick Creek Watershed has approximately 3200 acres of deciduous forest in the Monical and Orchard Creek watersheds. Nearly all of these forested areas are privately held and could be developed in the future. However, many of these areas have remained forested because of steep terrain that has little agricultural benefit, though they may be cultivated for forestry products. Preserving these large forested areas, to the extent possible, can help to keep water quantity and quality in good condition.

Pollutant Source Critical Areas

Brooklyn Auto Parts Dump

There are no specific locations that the Steering Committee identified that should receive special attention in regards to preserving existing high quality habitat. However, all expressed concern for preserving water quality within the intake zones of public wells. For example, there is concern that the tire dump in Brooklyn and the contaminated soil on that site will leach into the nearby Brooklyn potable water well field. Thus, the tire dump is a high priority for residents in the Town of Brooklyn.

Bacteria and Pathogens

Based on the water quality monitoring study conducted for this WMP and prior studies, selected sub-watersheds presented good opportunities to isolate and address bacterial loading to waterways in the Lower White Lick Creek Watershed. Selected sub-watersheds include the unnamed tributary just outside of Mooresville (Site 5), north tributary of the Monical Branch (Site 7 & 8), Orchard Creek (Sites 11 and 12), and the Silon Creek (IDEM identified impairment) watersheds. These sub-watersheds showed elevated and consistently high levels of *E. coli* bacteria, and in addition, these sub-watersheds have contributing areas where the source of the bacteria is more easily identified, located, and managed. At other monitoring locations, it is not possible to clearly isolate the contributing source area of the bacteria. If the monitoring location is located on a major tributary with several sub-watersheds, it is not possible to identify the source area clearly. Thus, those watersheds that have a clearly identified and manageable source area are given priority for addressing bacteria impairment in the study watershed.

Streams and Drainage Ditches

Nutrient, herbicide and pesticide contamination is non-point source issue where the most significant contribution is going to originate from those areas where the nutrients and chemical are applied, namely agricultural crop production. There are a significant number of un-buffered stream reaches throughout the study watershed where the installation of a buffer would help to reduce the amount of fine sediments, nutrients, and agricultural chemicals to the waterways. These areas are considered critical in that several water quality issues are addressed simultaneously. Buffered stream reaches would reduce fine sediment contributions, reduce nutrient transport to the waterways, provide shade to reduce in-stream temperatures that lower oxygen, provide habitat diversity for higher quality flora and fauna communities.

Illicit Trash/Dumping

One may find illicitly discarded trash at nearly any stream crossing in the Lower White Lick Creek Watershed. Those crossing that are more remote, however, are more favorable to those who wish to abandon their trash in an easily accessible location will as little chance to be noticed as possible. Therefore, stream crossings in rural areas tend to be the most impacted by illicit dumping. Items that are dumped can range from paint, and other household chemicals, to bicycles, mattresses, washing machines, tires, just about any household item that can be transported in the back of a pickup truck. These areas are considered critical because they are highly visible locations, the potential source of household toxins can be reduced, and existing laws already exist that forbid dumping of trash.

Public Golf Courses

There are 2 golf courses in the Lower White Lick Creek Watershed, and though it is not known the extent to which these facilities contribute nutrients, pesticides, and herbicides, the likelihood is high that they are sources of these contaminants to nearby waterways. Furthermore, nutrient, pesticide, and herbicide applications are not monitored or regulated in the areas where these golf courses are located. Therefore, these golf courses are mentioned as critical source areas that should be addressed in the Lower White Lick Creek WMP.

5.0 SETTING GOALS, MANAGEMENT MEASURES, AND INDICATORS

Setting realistic and measurable goals, management measures, and indicators is important for the successful implementation of this Plan. A goal is the desired change or outcome as identified in the watershed planning effort. Depending on the magnitude and extent of the problem, goals may be generic or specific, long-term or short-term. Goals stated in this Plan are general statements that address critical sources of NPS pollutants in the watershed. Along with the goal statement are management measures that describe in detail specific actions that can be taken to reach the stated goal. Finally, each management measure has an indicator specified whereby progress may be measured, tracked, and evaluated in the context of the goal. Indicators may be administrative, environmental, or social in nature. Administrative indicators involve administrative tasks, environmental indicators involve quantifiable physical features, and social indicators involve documented behavior changes. In subsequent Plan assessments and revisions, these goals, indicators, and objectives will be re-evaluated and revised as necessary to accommodate changing concerns and priorities of watershed constituents.

Industrial Waste Clean-up

Goal

To improve water quality in the Lower White Lick Creek Watershed through identification, acquisition, and clean-up of legacy toxic waste sources.

Management Measure

A) Initiate the Brooklyn Auto Parts Dump Acquisition and Clean-up. Purchase of the old auto parts dump and removing the contaminated soil is viewed as a high priority project to eliminate the potential for toxic contamination of the White Lick Creek and nearby drinking wells. Once the site has been cleaned, it will be set aside and protected in order to maintain floodplain capacity during flood events and to create a riparian area where nutrients and fine sediments may be removed during high flow events. After all toxic materials have been removed from the site; the property will be assigned a permanent conservation easement. The tire dump is located in the Town of Brooklyn as shown in Exhibit 11.

Industrial Waste Clean-up Indicator

a) PCB, other toxins, and heavy metal concentration in soil on site, target condition is to have near 100% removal complete in 2008.

Land Use Planning

Goal

To improve water quality in the Lower White Lick Creek Watershed through progressive land use planning and land development practices.

Management Measures

A) Create a mitigation database in a GIS that identifies potential riparian and wetland mitigation locations in the Lower White Lick Creek Watershed. This layer can be developed to identify and rank parcels along stream corridors and in other sensitive areas in the watershed that possess attributes that are conducive to wetland, or riparian wetland, creation. The intention of this management measure is to create a ready-made resource for developers and for local decision-makers to quickly and efficiently identify areas where mitigation may take place and is a proactive approach to helping ensure that if mitigation is required, that it is applied in locations that are most likely to succeed and provide the greatest benefit to water quality improvements.

B) Update and revise existing Comprehensive Planning document, Zoning Ordinances, and Sub-division Control for areas in the Lower White Lick Creek Watershed. Existing planning and zoning requirements that are effective in this study watershed do not address water quality issues. Updated ordinances may include sections that address the following:

- Erosion and sediment control ordinance
- Stormwater and drainage requirements
- Floodplain Management
- Wetland Protection
- Riparian Corridor Protection
- Tree preservation and protection
- Set-backs and buffer area protection
- Drainage easements (ROWs)
- Overlay zoning districts
- Treatment of sewage
- Limit the amount of impervious area
- Conservation design
- Flexible development standards
- Sanitation ordinance

Potential sources of non-point source pollution may be controlled and regulated through the Comprehensive Plan and ordinances.

C) Explore the feasibility of forming a Bi-county Watershed Planning Board for Hendricks and Morgan County. Watersheds in both counties cross jurisdictional boundaries and to address water quality issues only within those boundaries is problematic. Water quality and activities in Hendricks and Marion Counties do affect water quality down stream in Morgan County. Thus, for watershed management to be effective, it is imperative that all three counties work together to formulate solutions to managing water quality issues in the Lower White Lick Creek Watershed. This management measure would be a first step toward a cooperative planning effort that would better manage water quality issues across jurisdictions.

D) Develop a GIS database of various layers to help track and monitor growth and development in the Lower White Lick Creek Watershed. The intention of this management measure is to better view growth trends in relation to other watershed features that could have an impact on future water quality. A GIS is capable of comparing and overlaying several layers of information related to land use, soils, waterways, sensitive areas, and other landscape features whereby spatial relationships can be quickly assessed, identified and planned for visually.

E) Re-organize the Morgan County Watershed Initiative (MCWI). The MCWI was very active for previous watershed management plans, but has since ceased to be active. This group has shown a desire and interest in addressing water quality issues for the future well being of Morgan County residents. If re-organized, this group could invigorate communities throughout the County to focus on water quality issues and to help foster needed changes in water resource use and practices. At the same time, a "Watershed Coordinator" position would be created and would be responsible for facilitating the re-organization. Such a position may be funded through the IDEM and the 319 program.

Land Use Planning Indicators

a) Number of ownership plats identified that are adjacent to known NWI wetlands and areas suitable for wetland mitigation, initial target condition is to identify all land owners that are adjacent to NWI wetlands, ongoing to 2010.
b) Update Comprehensive Plan, Zoning Ordinances, and Sub-division Control, complete in 2010.
c) Conduct 1 meeting with Hendricks, Marion, and Morgan County planning authorities to discuss feasibility of a Tri-county Watershed Planning Board, complete in 2006.
d) Develop land use data for use in a GIS, ongoing to 2010.
e) Re-organize regular MCWI meetings and hire a Watershed Coordinator to facilitate the meetings and organize ongoing WMP implementation.

Human Waste Disposal

Goal

To improve water quality in the Lower White Lick Creek Watershed through proper planning, long-term maintenance, proper installation, and support for effective septic system function.

Management Measures

A) Conduct a septic system workshop for existing and future septic system owners. Many septic system owners may be unaware that their septic system is failing, or are not clear about how to maintain their septic system. This management measure is intended to raise awareness of the proper function of septic systems and then owners will voluntarily repair and maintain their systems.

B) Increase the detection of failing systems. The extent and magnitude of the failing septic system issue in the Lower White Lick Creek Watershed is not well understood or quantified. Currently, the contribution of bacteria by failing septic systems is assumed; however, there is little evidence gathered that clearly identifies septic systems as a significant source of bacteria in the waterways. This management measure would further the effort to better understand the problem and quantify actual contributions of bacteria by failing septic systems. Thus, future management decision can be made on information that more accurately characterizes the septic system issue.

C) Promote new septic systems technologies that are more appropriate for poorly draining soils. A large proportion of the soil types in the Lower White Lick Creek Watershed are not suitable for proper septic system function. There are technologies available that can be implemented that can provide a properly functioning septic system in such conditions. One such technology is sand mound infiltration fields for septic systems. Essentially an above ground infiltration field is constructed that filters waste products. The intention of this management measure is to actively seek innovative alternatives to current septic system practices that may not be appropriate for poorly drained soil conditions in the Lower White Lick Creek Watershed.

D) Create an amnesty program for failing septic systems. This type of program may help to encourage septic system owners to assess the condition of their septic system and, if found to be failing, can rectify the problem with no penalty to identify and fix the problem. If the amnesty program has a deadline date, then greater urgency may be applied to address the issue before a penalty phase would take effect. The intention of this management measure is to create an incentive and reward for private owners of septic systems to address the issue of failing septic systems proactively. Success of this management action is determined by the objective to reduce the daily contribution of bacteria by human sources to waterways by **50%**, from **1.4 x 10^{13} CFU/day to 7.0 x 10^{12} CFU/day**. This program would raise awareness, and help bring many failing systems into compliance with local regulations.

E) Improve the planning process related to septic system inspections and permitting. Currently, the Morgan County Health Department oversees the inspection and permitting of septic systems throughout the County. That responsibility can be aided by the addition of selected planning measures that can help to support the effort to keep septic systems functioning properly. The existing planning documents can be updated and revised to include guidance on the placement, inspection, and ongoing maintenance of septic systems. Adoption of a new ordinance that requires additional regulation of existing septic systems, over and above existing regulations, would help to support ongoing Morgan County Health department efforts to oversee septic systems in the watershed.

F) Explore the feasibility of creating a Septic Maintenance District. This management measure would help to support the effort to monitor and maintain septic systems in functioning order. The Septic Maintenance District would implement septic maintenance controls for public and private septic systems with results being a drastic reduction in the number of failing septic systems in the watershed.

G) Promote the use of POTWs where infrastructure costs are prohibitive to link to existing WWTPs. One alternative to the continued use of septic systems is to encourage the use of smaller scale treatment plants, especially for subdivision developments that are too remote from established WWTPs. This management measure is intended to remove a number of septic systems that currently may be failing, and to reduce the number of future septic systems that could be installed. A centralized waste water treatment facility is easier to regulate, is more efficient, and would help move communities away from problematic septic systems.

<u>Human Waste Disposal Indicators</u>

a) Number of attendees to the workshop. Present to 200 septic owners in the Lower White Lick Creek Watershed, complete in 2006.
b) Conduct targeted water quality testing for E. coli to better identify and isolate bacteria problem in all three watersheds that are indicated as having a bacteria concern in Exhibit 13. Conduct bacteria tracing tests, if necessary, to identify source of high bacteria loadings. Ongoing through 2010.
c) Monitor *E. coli*. level in waterways where new technology septic systems are installed and compare to WQS.
d) Number of applications for amnesty 1,876 and *E. coli.* concentration in tributaries. Target condition is to reduce the daily contribution of bacteria by human sources to waterways by 50%, from 1.4 x 10^{13} CFU/day to 7.0 x 10^{12} CFU/day. The estimated number of failing septics in the Lower White Lick Creek Watershed is 1,876; therefore, roughly 900 applications for amnesty would be close to half the daily contribution from human septic waste sources. Monitor E. coli levels in areas where owners have requested amnesty, Amnesty program complete in 2009.
e) Adoption of new ordinances that support and improve the planning and permitting process, ongoing from 2006.
f) At least one meeting held where all responsible parties discussed the feasibility of creating a Morgan County Septic Maintenance District, complete in 2006.
g) A workshop for Morgan County authorities that is attended by critical promulgation authorities, complete in 2007.

Household & Yard Waste

Goal

To improve water quality in the Lower White Lick Creek Watershed through efforts to properly dispose of household and yard wastes.

Management Measures

A) Promote and expand existing recycling program. The West Central Solid Waste District has managed a recycling program in the past. However, due to cutbacks in it budget and lack of strong public support the recycling program has been discontinued in Morgan County. The intent of this management measure is to utilize the amount of solid waste that is recyclable so that it does not end up in the waterways of the County.

B) Continue to sponsor special events such as the Tox-A-Way program. Similar to the recycling program, the Tox-A-Way program provides a location and temporary storage of more toxic chemicals that are generated from households. Some of these include paint thinners, paints, oils, anti-freeze, and used tires. These programs can be mobile, or stationary. The intent of this management measure is to provide the means to remove toxic household wastes safely and eliminate them from common areas and illegal dumps that could pollute water resources. The West Central Solid Waste District (WCSWD) is an independent government agency serving Hendricks, Montgomery, Morgan, Parke and Putnam Counties in Indiana. The WCSWD offers a variety of solid waste, waste reduction and recycling programs and services for residents, schools, businesses and government agencies. In past years, the WCSWD sponsored a Tox-A-Way and recycling program for the safe disposal of household hazardous waste. In addition, the Purdue Cooperative Extension has created a “Farm*A*Syst” and “Home-A-Syst” program that allows homeowners to conduct a confidential self-assessment of the environmental risks of their farm and home.

C) Conduct workshops on organic farming, planting with native species, and mulching. This management measure is intended to address nutrient, herbicide, and pesticide use on residential properties. Collectively, these residential properties have the potential to contribute significant amounts of nutrients and other chemicals to area waterways.

D) Erect signs at stream crossings that identify the stream as a sensitive watershed area and warn of legal consequences for illegal dumping in that sensitive area. The intent of this management measure is to raise public awareness about an illegal activity, promote public responsibility for a sensitive area, and inform violators of the consequences if caught dumping trash illegally.

Household and Yard Waste Indicators

a) Expansion of the existing recycling program by 5%, ongoing through 2010.
b) Continuation and expansion of the Tox-A-Way program by 5%, ongoing annually to 2010.
c) Number of attendees to the workshops. Attempt to reach 100 interested individuals, complete in 2006.
d) Number of signs erected in Lower White Lick Creek Watershed. Target condition is to erect 50 signs (2 at every major stream crossing) in the Lower White Lick Creek Watershed, complete in 2007.

Crop & Livestock Production

Goal

To improve water quality in the Lower White Lick Creek Watershed through continued support for educational programs, incentive programs, and support for innovative agricultural practices.

Management Measures

A) Promote nutrient and pesticide management practices that retain or increase agricultural production and help to improve water quality. This management measure does not prescribe an actual management practice; rather, it intends to promote educational and technical activities in the community. Currently, the Morgan County SWCD is active in promoting nutrient and pesticide management and works closely with the NRCS to provide educational resources and opportunities to implement these innovative technologies.

B) Support the Morgan County SWCD in all educational outreach efforts. The intention of this management measure is to affirm continued support for the mission and activities of the Morgan County SWCD office on providing and disseminating information related to soil and water conservation in the communities.

C) Initiate an Organic Growers Certification Program. Certification of organic farmers can help to raise public awareness of the group, grant it greater legitimacy, and provide a mechanism that helps to assure that produce grown under an organic certification has been authorized and confirmed that no herbicides or pesticides were used during production. The intent of this management measure is to help promote the participation in organic farming that could remove some of the pesticide and herbicide inputs to the Lower White Lick Creek Watershed.

D) Promote filter strips and conservation buffers in the Lower White Lick Creek Watershed. Filter strip and conservation buffers can trap fine sediments that can carry nutrients and pesticides and can provide some uptake of nutrients as well. If a portion of the 485 acres of un-buffered reaches, such as 50 acres of filter strips, could be established in the watershed, it may be possible to reduce the amount of sediment delivered to waterways by 48 tons/year, phosphorous by 82 lbs/year, and nitrogen by 153 lbs/year. A sample calculation is provided in **Appendix 4**. This management measure does not explicitly prescribe the installation of filter strips or conservation buffer at a specific location, but does support the promotion of the techniques for retarding or trapping pollutants before they reach the waterways.

E) Promote and demonstration program for farmers to adopt no-till cultivation practices and filter strip establishment. Conventional tillage practices may contribute to nutrient and sediment loading to waterways in the Lower White Lick Creek Watershed. If successful in converting 25% of the estimated 3840 acres that are currently in conventional tillage to no-till practices, then reductions in total phosphorous and nitrogen delivered to waterways may be realized. Load reduction for this management measure is identical to the loading reduction estimated for the above Filter Strip measure. Source areas treated in no-till cultivation would essentially be the same as a 100'-wide buffer on both banks for all fields that are adjacent to identified waterways. This management measure is intended to jump start farmer interest and adoption of new farming practice in the Lower White Lick Creek Watershed.

Crop and Livestock Production Indicators

a) Address 50 farmers through the workshops, ongoing through 2010.
b) Continuation and expansion of SWCD educational efforts in the Lower White Lick Creek Watershed, ongoing through 2010.

c) Application and approval of Organic Growers Certification Program for Morgan County, to be complete in 2007.
d) Phosphorous and nitrate-nitrogen as measured in the waterways. There is no WQS for these nutrients, yet. Establishment of 242 acres of filter strips, to be complete in 2010.
e) Establish a demonstration location that showcases an example of no-till and filter strip BMPs in Study Watershed, complete in 2007.

Natural & Constructed Waterways

Goal

To improve water quality in the Lower White Lick Creek Watershed through the promotion of protection and maintenance of streams and drainage ditches.

Management Measures

A) Conduct a workshop on stream buffers. This management measure is intended to inform farmers of the protective benefits to waterways that buffers provide. Additionally, these workshops can provide an opportunity to explore how buffers can benefit farmers through soil loss prevention in upland, as well as, waterway areas.

B) Write a Greenways Plan. The intention of this management measure in to plan for and protect areas that may serve both as water quality protection areas and as a community recreational resource. A Greenways Plan that includes and expands on currently set aside areas would help to improve water quality conditions and provide a positive community resource.

C) Promote streambank stabilization throughout the watershed. Un-buffered reaches of the White Lick Creek and its tributaries should receive priority for bank stabilization activities as it is important to re-establish vegetation to hold firm the bank material. If 10,560 feet (2.0 miles) of streambank stabilization were established (roughly 10% of all un-buffered streams), it may be possible to reduce the amount of sediment load by 1,077 tons/year, Phosphorous by 1,077 lbs/year, and nitrogen by 2,154 lbs/year. A sample calculation is provided in Appendix 4.

Natural and Constructed Waterways Indicators

a) Address 50 farmers through the riparian buffers workshop, complete in 2006.
b) Adoption of a Greenways Plan in one or both identified critical areas in Exhibit 13, complete in 2010.
c) Total suspended solids, phosphorous, and nitrogen measurements. There are no recognized WQS for Indiana for these pollutants at this time. General reduction in loading is sought through the establishment of approximately 11,000 feet of streambank stabilization, to be complete in 2010.

Implementation

Successful implementation of the Plan requires that resources, programs, and funds be identified. It is important to have the support of individuals that can successfully execute the goals of the Plan. Successful implementation may require some legal matters, such as permit programs, easements and ordinances to be adopted and enforced. The above management measures are presented in **Table 5-1** with tasks, estimated action date, milestones, and resources required to accomplish the measure. Additionally, **Table 5-2** presents an action timetable that may be used as a general schedule to help implement the Plan.

Table 5-1: Action Register

Goal	Management Measures	Action Date	Responsible Party	Resources Needed
Industrial Waste Clean-up	**A) Toxic Waste Clean-up and re-testing.**	2006 - 2010	MC Health Dept MC Surveyor County Commissioners County Parks Board	• $45,000 – Land purchase • $300,000 – Cleanup costs • Easement placed on property
Land Use Planning	**A) Mitigation Database** • Consult with a wetlands specialist on the project direction and objective. • Develop a digital soils map, contour map, parcels map, NWI info, detailed hydrography, and other relevant layers. • Overlay these layers and identify areas where criteria best suited for wetlands are indicated. • Compile the parcels identified.	2006 - 2010	MC Planning Dept MC Surveyor Mooresville Planning Brooklyn Planning MC SWCD All County Parks	• GIS system • Capital and labor to gather and develop layers • GPS unit, or rental unit. • Funding for wetland consultant • ~ $10,000
	B) Planning Updates • Participate in the update of the Comprehensive Plan for Morgan County. • Participate in the update of the Zoning Ordinance and Subdivision Control Ordinance for Morgan County.	Ongoing to 2010	MC SWCD MC Planning Dept	• Cooperation from Plan Commission • List of definitions, suggested language, and model ordinances. • Moderate administrative costs
	C) Bi-county Watershed Board • Hold a meeting with water resource related planning officials from Morgan and Hendricks Counties to discuss the feasibility of forming a Bi-county Watershed Planning Board.	2006	MC SWCD MCWI Morgan Co Surveyor Hendricks Co Surveyor	• Administrative organization/support • Meeting location • Cooperation from Marion & Hendricks Counties.

Goal	Management Measures	Action Date	Responsible Party	Resources Needed
	D) GIS System • Consult with an IT professional familiar with GIS set-up. • Plan hardware and software setup. • Purchase hardware and software • Hire, or assign, a GIS Manager to maintain the GIS system. • Install system and train users • Develop data layers for planning and archiving geographic and other data.	2006 – 2010 (pending I-69 data)	MC Surveyor MC Planning Dept MC SWCD MC Auditor All agencies of Morgan County Government	• Cost of IT consulting Services. • Cost for hardware and software. • Administrative management • New GIS position. • Cost of training users. • Ongoing IT/GIS maintenance • Funding would be sought from outside sources. • $50,000 - $100,000
	E) Morgan County Watershed Initiative • Explore the feasibility of hiring a Watershed Coordinator with 319 Grant Funds to organize and implement management measures recommended in this WMP. • Organize and re-convene a MCWI meeting. • Assess interest in re-forming the group.	2006 - 2010	MC SWCD	• 319 Grant funds for Watershed Coordinator • $30,000 - $45,000/year
Human Waste Disposal	**A) Septic System Workshop** • Identify septic system owners, especially in the critical area sub-watersheds. • Conduct the workshops.	2006	MC Health Dept MC SWCD	• Administrative organization • Presentation Materials • Location for demonstration.

Goal	Management Measures	Action Date	Responsible Party	Resources Needed
	B) Failing Septic System Detection • Survey channels and streams for pipe outfalls and record locations with GPS unit. • Initiate dye tests on residents in the Orchard Creek and other critical area sub-watersheds.	2006 - 2010	MC Health Dept MC Surveyor MC SWCD	• Field crew • Cooperation to travel all waterways and record pipe outfall locations. • GPS Unit (rental) • Sanitary Inspector time to conduct tests. • $30,000/year
	C) New Septic Technology • Research new technologies. • Develop flyer and distribute to septic owners. • New applications for septic installations should be examined for soil conditions.	2006, ongoing	MC Health Dept MC SWCD	• Requires Health Dept approval and cooperation • Administrative support • $5000 - $10,000
	D) Amnesty Program • Develop the details of the program. • Communicate the program to every septic system owner, or potential owner via mail, radio, newspaper, and T.V. • Enlist those who choose participate, and provide assistance to those who participate.	2006 - 2010	MC Health Dept MC Planning Commission	Morgan County Health Dept cooperation Administrative support

Goal	Management Measures	Action Date	Responsible Party	Resources Needed
	E) Improve Planning Process • Ensure that Health Dept. participates in development review and approval process. • Include language in updated Comprehensive Plan that addresses potential impacts of septic systems on water quality. • Build a GIS layer that identifies land areas suitable for standard septic system design.	2006 – 2008	MC Health Dept MC SWCD MC Surveyor	Health Dept & Planning Commission GIS employee, or contract worker in GIS
	F) Septic Maintenance District • Research information on Septic Maintenance Districts – funding and operation.	2010	MC Planning Commission MC Health Dept	Administrative overhead
	G) POTWs • Promote POTWs for new residential developments over 50 units.	2006 - 2010	MC SWCD MC Health Department IN Board of Health MC Planning Commission	• Local sewer infrastructure • Pumps • Maintenance and operation
Household & Yard Waste	**A) Support & Expand Existing Recycling Program** • Explore methods to generate public support for the recycling program • Investigate ways to make recycling program pay for itself.	2006	WCSWD MC SWCD	WCSWD budget

Goal	Management Measures	Action Date	Responsible Party	Resources Needed
	B) Sponsor Tox-A-Way Program • Explore methods to generate public support and awareness of Tox-A-Way program • Investigate ways to make Tox-A-Way program pay for itself.	2006	MC SWCD WCSWD	MC SWCD budget
	C) Organic Farming Workshops • Identify target audience • Market the workshop • Conduct workshop	2007	MC SWCD Hoosier Heartland RC&D	MC SWCD budget
	D) Signs at Water Crossings • Design content of signs • Seek funding to produce signs • Identify key locations for installation • Install signs prominently at selected crossings	2006	MC SWCD MS Highway Department	• Funds to produce • signage • Approval where needed • Committee to design and organize installation. • Boy/Girl Scout Project to install signs (public service project). • Grants • $1000 - $5000
Agricultural Practices	**A) Nutrient & Pesticide Mgt** • Produce and distribute education materials. • Present nutrient and pesticide application management to landowners and farmers.	2006	MC SWCD	• MC SWCD Budget • Grants • Cost-share programs

Goal	Management Measures	Action Date	Responsible Party	Resources Needed
	B) SWCD Support • Prepare educational displays. • Participate in 4 events annually to present WQ issues. • Conduct field days in the watershed to demonstrate watershed processes and water quality measurements.	Ongoing to 2010	MCWI (if active)	• MCWI
	C) Promote USDA Organic Certification Program • Research funding to encourage participation in the Indiana Organic Certification Program • Enlist organic growers in the Indiana certification program	2006	MC SWCD NRCS Purdue Extension USDA ISDA	• Certification requirements • USDA • NRCS
	D) Promote Filter Strips • Identify all land owners willing to provide land as a demonstration project. • Identify funding programs for installation • Install approximately 50 acres of filter strips. • Conduct tours of the BMP.	2006 - 2010	MC SWCD	• Part of MC SWCD budget • 319 implementation funds • Willing land-owner to demonstrate the filter strip. • Operation & maintenance costs. • $5000 - $7000
	E) Promote Demonstration of Conservation Farming Practices • Identify a land owner willing to demonstrate the BMP. • Also contact Future Farmers to explore a partnership • Identify funds to install BMP • Install BMP ~ 1 – 2 acres. • Conduct tours of the BMP.	2006 - 2010	MC SWCD NRCS Future Farmers Purdue Extension	• 319 Grant funds • NRCS Grant funds • Operation & maintenance costs. • $1000 - $2,000

Goal	Management Measures	Action Date	Responsible Party	Resources Needed
Natural & Constructed Waterways	**A) Riparian Buffer Workshop** • Identify target audience • Market the workshop • Conduct workshop	2006 - 2010	MC SWCD NRCS	• Farmer • MC SWCD lead • 319 or other Funds • Time & Materials for tours
	B) Greenways Plan • Work with landowners, planners, SWCD staff, Morgan, Marion, and Hendricks Counties, and Indianapolis International Airport to develop a Greenways Plan.	2006 - 2010	MC Plan Commission MC SWCD Mooresville Brooklyn Parks Department IDNR County Commissioners	• Support and interest of landowners, SWCD, and planning departments • Secure additional funds to pay for study writing, and distribution of the plan. • Moderate cost.
	C) Streambank Stabilization • Identify and prioritize areas and property owners needing buffers. • Install 11,000 feet of streambank stabilization measures in un-buffered reaches. • Research funding opportunities for streambank stabilization	Ongoing to 2010	MC SWCD Surveyor NRCS Landowners	• Federal funding • Private funds • MC SWCD budget • $500,000 - $1,000,000

Table 5-2: Action Timeline

Category	Management Measure Milestone	YEAR				
Industrial Waste Clean-up	**A) Toxic Waste Clean-up and re-testing.**	2006	2007	2008	2009	2010
Land Use Planning	**A) Mitigation Database**	2006	2007	2008	2009	2010
	• Consult with a wetlands specialist on the project direction and objective.	2006				
	• Develop a digital soils map, contour map, parcels map, NWI info, detailed hydrography, and other relevant layers.	2006				
	• Overlay these layers and identify areas where criteria best suited for wetlands are indicated.	2006	2007	2008	2009	2010
	• Compile the parcels identified.			2008	2009	
	B) Planning Updates	2006	2007	2008	2009	2010
	• Participate in the update of the Comprehensive Plan for Morgan County.	2006				
	• Participate in the update of the Zoning Ordinance and Subdivision Control Ordinance for Morgan County.	2006	2007	2008	2009	2010
	C) Bi-county Watershed Board	2006	2007	2008	2009	2010
	• Hold a meeting with water resource related planning officials from Morgan and Hendricks Counties to discuss the feasibility of forming a Bi-county Watershed Planning Board.	2006	2007	2008	2009	2010
	D) GIS System	2006	2007	2008	2009	2010
	• Consult with an IT professional familiar with GIS set-up.	2006				
	• Plan hardware and software setup.	2006	2007	2008	2009	2010
	• Purchase hardware and software	2006				
	• Hire, or assign, a GIS Manager to maintain the GIS system.	2006				
	• Install system and train users	2006	2007			

	• Develop data layers for planning and archiving geographic and other data.		2007	2008	2009	2010
	E) Morgan County	2006	2007	2008	2009	2010
	Watershed Initiative	2006				
	• Explore the feasibility of hiring a Watershed Coordinator with 319 Grant Funds to organize and implement management measures recommended in this WMP.	2006				
	• Organize and re-convene a MCWI meeting.	2006				
	• Assess interest in re-forming the group.	2006				
Human Waste Disposal	**A) Septic System Workshop**	2006	2007	2008	2009	2010
	• Identify septic system owners, especially in the critical area sub-watersheds.	2006	2007	2008	2009	2010
	• Conduct the workshop.	2006		2008		
	B) Failing Septic System Detection					
	• Survey channels and streams for pipe outfalls and record locations with GPS unit.	2006	2007	2008	2009	2010
	• Initiate dye tests on residents in the Orchard Creek and other critical area sub-watersheds.		2007	2008	2009	
	C) New Septic Technology	2006				
	• Research new technologies.	2006				
	• Develop flyer and distribute to septic owners.	2006				
	• New applications for septic installations should be examined for soil conditions.	2006				
	D) Amnesty Program	2006	2007	2008	2009	2010
	• Develop the details of the program.	2006				
	• Communicate the program to every septic system owner, or potential owner via mail, radio, newspaper, and T.V.		2007	2008		
	• Enlist those who choose participate, and provide assistance to those who participate.			2008	2009	

	E) Improve Planning Process	2006	2007	2008	2009	2010
	• Ensure that Health Dept. participates in development review and approval process.	2006				
	• Include language in updated Comprehensive Plan that addresses potential impacts of septic systems on water quality.	2006	2007			
	• Build a GIS layer that identifies land areas suitable for standard septic system design.		2007	2008	2009	
	F) Septic Maintenance District					
	• Research information on Septic Maintenance Districts – funding and operation.	2006	2007	2008		
	G) POTWs	2006	2007	2008	2009	2010
	• Promote POTWs for new residential developments over 50 units.	2006	2007	2008	2009	2010
Household & Yard Waste	**A) Support & Expand Existing Recycling Program**	2006	2007	2008	2009	2010
	• Explore methods to generate public support for the recycling program	2006	2007	2008	2009	2010
	• Investigate ways to make recycling program pay for itself.	2006	2007	2008	2009	2010
	B) Sponsor Tox-A-Way Program	2006	2007	2008	2009	2010
	• Explore methods to generate public support and awareness of Tox-A-Way program	2006	2007	2008	2009	2010
	• Investigate ways to make Tox-A-Way program pay for itself.	2006	2007	2008	2009	2010
	C) Organic Farming Workshops	2006		2008		2010
	• Identify target audience	2006		2008		2010
	• Market the workshop	2006		2008		2010
	• Conduct workshop	2006		2008		2010
	D) Signs at Water Crossings	2006	2007			
	• Design content of signs	2006				

	• Seek funding to produce signs	2006				
	• Identify key locations for installation	2006	2007			
	• Install signs prominently at selected crossings	2006	2007			
Agricultural Practices	**A) Nutrient & Pesticide Mgt**	2006	2007	2008	2009	2010
	• Produce and distribute education materials.	2006	2007	2008	2009	2010
	• Present nutrient and pesticide application management to landowners and farmers.	2006	2007	2008	2009	2010
	B) SWCD Support	2006	2007	2008	2009	2010
	• Prepare educational displays.	2006	2007	2008	2009	2010
	• Participate in 4 events annually to present WQ issues.	2006	2007	2008	2009	2010
	• Conduct field days in the watershed to demonstrate watershed processes and water quality measurements.	2006	2007	2008	2009	2010
	C) Promote USDA Organic	2006	2007	2008		
	Certification Program	2006	2007	2008		
	• Research funding to encourage participation in the Indiana Organic Certification Program	2006	2007	2008		
	• Enlist organic growers in the Indiana certification program	2006	2007	2008		
	D) Promote Filter Strips	2006	2007	2008	2009	2010
	• Identify all land owners willing to provide land as a demonstration project.	2006				
	• Identify funding programs for installation	2006				
	• Install approximately 50 acres of filter strips.		2007			
	• Conduct tours of the BMP.			2008	2009	2010
	E) Promote Demonstration of Conservation Farming Practices	2006	2007	2008	2009	2010
	• Identify a land owner willing to demonstrate the BMP.	2006				

	• Also contact Future Farmers to explore a partnership	2006				
	• Identify funds to install BMP	2006				
	• Install BMP ~ 1 – 2 acres.		2007			
	• Conduct tours of the BMP.			2008	2009	2010
Natural & Constructed Waterways	**A) Riparian Buffer Workshop**	2006		2008		2010
	• Identify target audience	2006		2008		2010
	• Market the workshop	2006		2008		2010
	• Conduct workshop	2006		2008		2010
	B) Greenways Plan	2006	2007	2008	2009	2010
	• Work with landowners, planners, SWCD staff, Morgan, Marion, and Hendricks Counties, and Indianapolis International Airport to develop a Greenways Plan.	2006	2007	2008	2009	2010
	C) Streambank Stabilization	2006	2007	2008	2009	2010
	• Identify and prioritize areas and property owners needing buffers.	2006				
	• Install 11,000 feet of streambank stabilization measures in un-buffered reaches.		2007	2008	2009	2010
	• Research funding opportunities for streambank stabilization	2006				

6.0 MONITORING EFFECTIVENESS

Progress indicators are used to gauge the progress and success of the watershed planning effort. Indicators may be administrative, such as language added to an ordinance, or programmatic, indicating the total acreage added to a filter strip program. Assigning dates to progress indicators is an effective method to ensure that the implementation of the WMP stays on target. Thus, monitoring describes how the above mentioned indicators will be evaluated to determine the level of success reached toward achieving the goal. Monitoring progress can be general, or very specific, such as increasing the number of participants at quarterly meetings or through improvements observed in biological or chemical measurements. Maintaining a list of successful programs and policies as a result of this WMP will help keep the momentum of the planning effort propelled forward.

Goal Monitoring

For each goal, it is suggested that progress toward meeting each indicator be documented on a quarterly basis. This documentation will provide a process by which progress may be tracked and the status of completion be reported to the Morgan County SWCD Board on a quarterly basis. Quarterly tracking of progress for each milestone will help to maintain focus on goal objectives and progress, but also to troubleshoot issues where it is clear that tasks may need to be adjusted or modified in order to achieve the goal objective.

Plan Evaluation

The Morgan County SWCD will be responsible for the regular review and update of the Lower White Lick Creek WMP. This Plan should be evaluated on an annual basis to document and celebrate progress; assess effectiveness of efforts; modify activities to better target water quality issues; and keep implementation of the Plan on schedule. The Plan should be revised as needed to better meet the needs of the watershed stakeholders and to meet water quality goals.

Chemical Monitoring Re-evaluation

In 2010, chemical monitoring of the Lower White Lick Creek Watershed at the same 12 monitoring locations that were used for this study will be conducted in order to evaluate if management measures are having a beneficial impact on water quality. A comparison and analysis of these findings can then be used to help direct future watershed planning and management activities.

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